Appendix D: Conservation Action Planning and Rapid Assessment Methods

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1.1 INTRODUCTION

As described in Chapter 4 (Methods) of the Plan, NOAA's National Marine Fisheries Service (NMFS) assessed watershed conditions and threats using a method called Conservation Action Planning (CAP). Results from our CAP analyses were output into tables using updated Miradi software. Miradi software is "the next generation" of the CAP protocol. Two types of analyses were conducted to assess current conditions and threats for selected California Coastal (CC) Chinook salmon, Northern California (NC) and Central California Coast (CCC) steelhead populations. The larger independent populations expected to achieve a low extinction risk threshold were analyzed using the full CAP protocol and individual CAP workbooks. The smaller dependent populations and independent populations expected to achieve a moderate extinction risk threshold were analyzed using an abbreviated rapid assessment protocol based on the CAP protocol at the Diversity Stratum level. The rapid assessments utilized a subset of the factors analyzed in the full CAP protocol. This report provides the rationale, analysis steps, and references used to assess current conditions and future threats for NC and CCC steelhead, and CC Chinook salmon. The CAP and rapid assessment results were used to set priorities for recovery and develop recovery actions targeted at improving conditions and reducing threats.

1.2 CONSERVATION ACTION PLANNING OVERVIEW

The Nature Conservancy's (TNC) CAP protocols were developed by the Conservation Measures Partnership, a partnership of ten different non-governmental biodiversity organizations including TNC. CAP is TNC's version of the Partnership's "Open Standards for the Practice of Conservation"[1]. CAP provides a structured approach to assessing conditions, stresses, and threats, and their relative importance to the species' status. It is one assessment method recommended in the Interim Recovery Planning Guidance (NMFS 2010). CAP is a Microsoft Excel-based tool with specific protocols to organize a project, assess conditions and threats, and identify actions. The Excel workbook warehouses all data for the project including assessment methods, results and references. In 2006, the North Central Coast Office (NCCO) Recovery Team adopted CAP for recovery planning work and partnered with TNC for training and support on the CAP protocol. Habitat, viability, and threat conditions were assessed using CAP or rapid assessments protocols for all populations selected for the recovery scenario.

Each CAP workbook represents an ESU or DPS population and has two assessment components: viability and threats (Figure 1, Figure 2). NMFS used the CAP protocol to: (1) develop a standardized analysis across all life stages and populations for each DPS or ESU; (2) characterize current conditions for key habitat attributes across freshwater life stages essential for salmonid survival; and (3) identify threats reasonably expected to

[1] For more information, see www.conservationmeasures.org.

continue to occur into the future that will have a direct or indirect effect on life stages for each population.

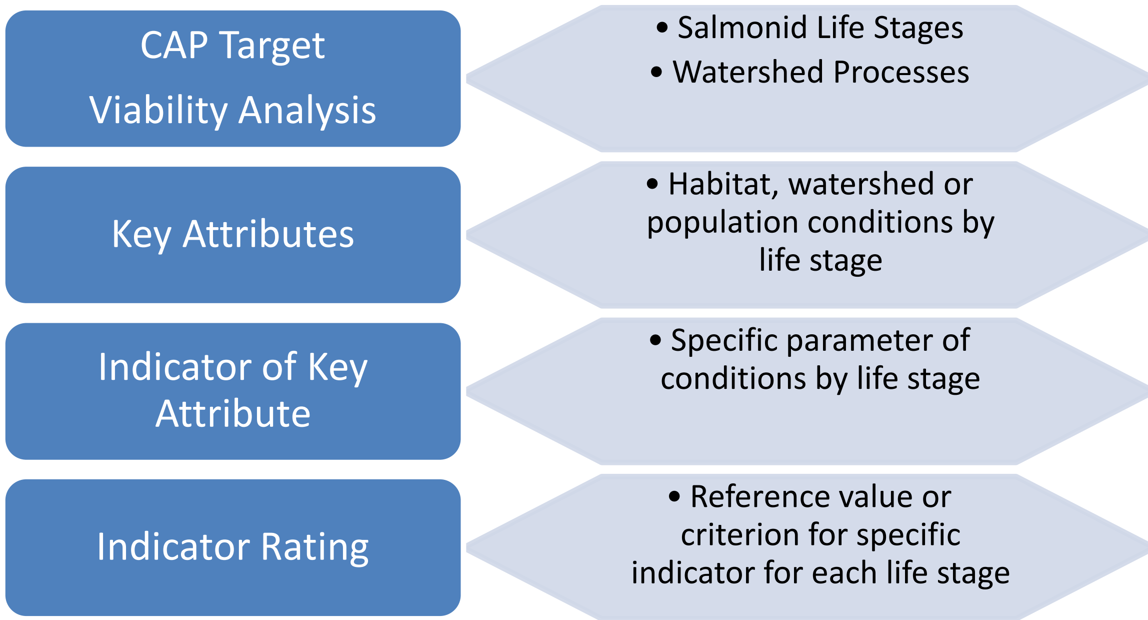

Figure 1. Structure of CAP workbooks for viability analysis.

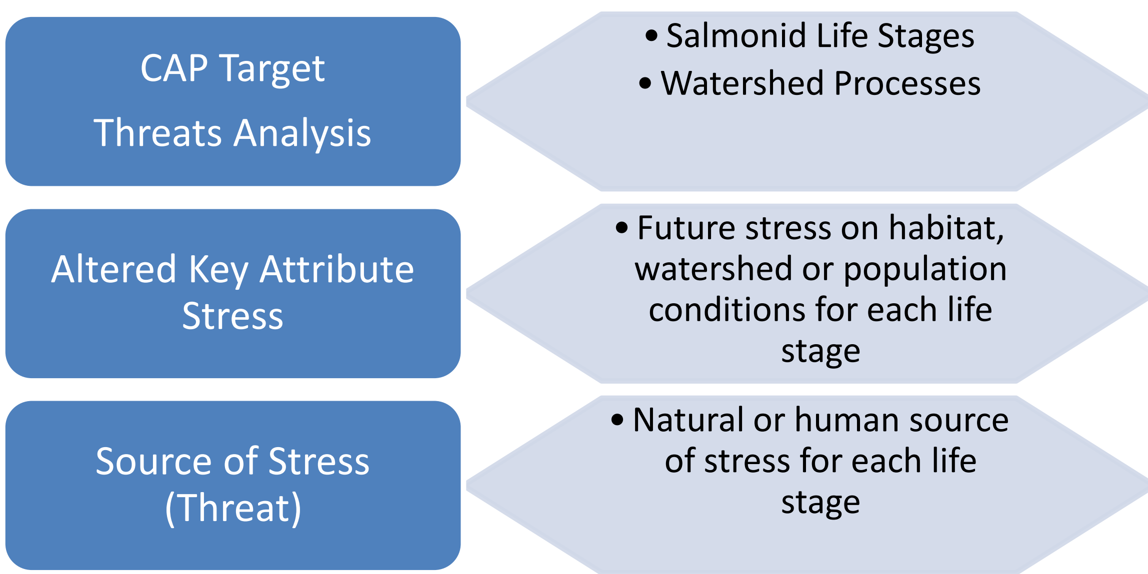

Figure 2. Structure of CAP workbooks for threat analysis.

Data inputs are computed by CAP algorithms to produce viability and threat results. Because the same assessment is conducted across populations, results were organized into tables by ESU/DPS, Diversity Stratum, population and life stage to provide a snapshot of conditions and threats. These results were used to formulate recovery actions designed to improve current conditions (restoration actions) and abate future threats (threat reduction actions). CAP can also track and summarize large amounts of information for each population over time, and can be adapted and iterative as new information becomes available. CAP will be used to update our assessments and track recovery criteria overtime. Ideally, agencies, watershed organizations and others will use the CAP workbook and associated data to inform data gaps, focus efforts and provide feedback and information to NMFS during the five year reviews of recovery plans.

1.3 ASSESSING CONDITIONS: CAP AND RAPID ASSESSMENTS

Conditions are assessed using the viability table of each CAP workbook and rapid assessment. Viability describes the status or health of a population of a specific plant or animal species (TNC 2007). More generally, viability indicates the ability of a conservation target to withstand or recover from most natural or anthropogenic disturbances and thereby persist for many generations or over long time periods. For the purposes of recovery planning, conservation targets are the specific life stages for each species and life stage viability is assessed using key attributes, indicators and indicator ratings on the viability page of the workbook.

1.3.1 CONSERVATION TARGETS

The viability of a salmon or steelhead population relies on an individual salmonid surviving across all of its life stages, and life stage survival depends on habitat conditions, natural events and anthropogenic factors. Since a population's viability relies on the conditions and threats associated with life stages, life stages were identified as the conservation targets for each CAP workbook. A final target facilitated assessment of large scale watershed processes. Each life stage is supported by both spatial and temporal processes that are often qualitatively or quantitatively measurable.

The CCC and NC steelhead life stages assessed as conservation targets were: adults, eggs, summer rearing juveniles, winter rearing juveniles and smolts, and in some populations of NC steelhead, summer adults. The CC Chinook life stages assessed as conservation targets were: adults, eggs, pre smolt and smolt. These life stages are defined below. These same targets were used in both the CAPs and the rapid assessments.

- Adults – Includes the period when adult salmonids enter freshwater, through their upstream migration, and subsequent spawning. For the purposes of our analysis, we considered late fall through spring as the migration season for both immigrating and emigrating (*i.e.*, kelts) adult winter steelhead; and the fall through early winter period for upstream migrating adult Chinook salmon;

- Summer Adult (NC steelhead only) – Includes the period when adult summer-run steelhead enter freshwater, through their upstream migration, and rearing period prior to spawning. For the purposes of our analysis, we considered spring through fall for the migration and staging period for adult summer run steelhead;
- Egg – Includes fertilized eggs placed in spawning redds, and the incubation of these eggs through the time of emergence from the gravel as fry. For the purposes of our analysis, we considered winter through spring to be the incubation period for steelhead; and from late fall through winter for Chinook salmon;
- Summer Rearing (steelhead only) – Includes rearing of juveniles from emergence as fry to the onset of early fall rains. This also includes pre-smoltification summer rearing of juveniles in estuaries and freshwater lagoons. For the purposes of our analysis, we considered late spring through early fall to be the summer rearing period for steelhead;
- Winter Rearing (steelhead only) – Includes winter rearing of juvenile steelhead from the onset of fall rains through the spring months (typically fall through early spring). This also includes significant main stem rearing for steelhead juveniles that utilize floodplain and off-channel habitats during high winter flow events;
- Pre-smolt (Chinook salmon only) - Includes rearing of Chinook salmon from the time of emergence as fry through the transition to emigration. This life stage also includes significant main stem rearing prior to complete smoltification. For the purposes of our analysis, we considered winter through spring to be the rearing period for pre-smolt Chinook salmon;
- Smolt – Includes downstream riverine residency of emigrating juvenile salmonids prior to ocean entry and estuarine residency where smolts may undergo additional growth and physiological changes, as they adapt to the marine environment. For the purposes of our analysis, the riverine period is considered to occur from late fall through spring for steelhead; and spring for Chinook salmon. For the purposes of our analysis, the estuarine period may generally persist late into the fall months, or until the first rains occur.
- Watershed processes - Includes landscape scale patterns related to land use for all species.

1.3.2 Viability Table: Key Attributes

Key attributes are defined as critical components of a conservation target's biology or ecology (TNC 2007). Attributes in CAP have been identified as needed for successful transitions between life stages leading to abundant and well-distributed populations. If attributes are missing, altered, or degraded then it is likely the species will experience more difficulty moving from one life stage to the next. There are three categories of key attributes for each CAP workbook: (1) habitat condition; (2) landscape context; and (3) viability. Attributes have a suite of indicators and indicator ratings by which to assess current conditions.   The rapid assessments were conducted using a subset of the attributes. Each attribute is described in detail in section 1.4, "Assessing Conditions: Key Attributes and Stresses".

1.3.3 Viability Table: Indicators and Indicator Ratings

Indicators are specific habitat, watershed process or population parameters used to assess the status of a key attribute. An attribute may have one or more indicators with qualitative or quantitative values detailing the likelihood of the attribute to support life stage survival and transition (*i.e.*, indicator rating). Ratings apply to specific life stages or watershed processes at a population level based on data from reach, stream or watershed spatial scales. These indicator ratings were derived from published scientific literature and other best available information regarding habitats and their relative importance to life stage survival (Table 1).

Table 1. CAP attributes and indicators for each species and life stage. Attribute categories vary between steelhead and Chinook salmon to reflect their different life history requirements.

Key Attribute	CAP Indicator	CAP Target (Life Stage)
Estuary/Lagoon	Quality and Extent	Steelhead - Summer Rearing, Smolts
		Chinook - Adult, Pre Smolt, Smolts
Habitat Complexity	LWD (BFW 0-10 and BFW 10-100)	Steelhead - Adults, Summer Rearing, Winter Rearing, Smolts
		Chinook - Adults
	Shelter Rating	Steelhead - Adults, Summer Rearing, Winter Rearing
		Chinook - Pre Smolt, Smolts
	Percent Primary and Staging Pools	Steelhead - Summer Rearing (Primary pools)
		Chinook - Adults (Staging Pools), Pre Smolt (Primary Pools)
	Pool/Riffle/Flatwater Ratio	Steelhead - Adults, Summer Rearing, Winter Rearing
		Chinook - Adults, Pre Smolt
	V* Star (Pool Volume)	Steelhead - Adults, Summer Rearing, Winter Rearing
		Chinook - NA
Hydrology	Redd Scour	Steelhead - Eggs
		Chinook - Eggs
	Flow Conditions (Baseflow and Instantaneous)	Steelhead - Eggs (Instantaneous) Summer Rearing (both), Summer Adults (Baseflow)
		Chinook - Eggs (instantaneous), Pre Smolt (both), Smolts, (Instantaneous)
	Passage Flows	Steelhead - Adults, Smolts, Summer Adults
		Chinook - Adults, Pre Smolt, Smolts
	Impervious surfaces	Steelhead - Watershed Processes
		Chinook - Watershed Processes
	Number, Conditions, and/or Magnitude of Diversions	Steelhead - Summer Rearing, Smolts
		Chinook - Pre Smolt, Smolts
Landscape Patterns	Agriculture	Steelhead - Watershed Processes
		Chinook - Watershed Processes
	Timber Harvest	Steelhead - Watershed Processes
		Chinook - Watershed Processes
	Urbanization	Steelhead - Watershed Processes
		Chinook - Watershed Processes
Passage/Migration	Passage at Mouth or Confluence	Steelhead - Adults, Summer Rearing, Smolts, Summer Adults
		Chinook - Adults, Pre Smolt, Smolts
	Physical Barriers	Steelhead - Adults, Summer Rearing, Winter Rearing, Summer Adults
		Chinook - Adults, Smolts
Riparian Vegetation	Tree diameter (North and South)	Steelhead - Adults, Summer Rearing, Winter Rearing
		Chinook - Adults, Pre Smolt
	Canopy Cover	Steelhead - Summer Rearing
		Chinook - NA
	Species Composition	Steelhead - Watershed Processes
		Chinook- Watershed Processes

Key Attribute	CAP Indicator	CAP Target (Life Stage)
Sediment	Quantity & distribution of Spawning Gravels	Steelhead - Adults, Summer Adults
		Chinook - Adults
	Gravel Quality (Bulk)	Steelhead - Eggs, Summer Adults
		Chinook - Eggs
	Gravel Quality (Embeddedness)	Steelhead - Eggs, Summer Adults
		Chinook - Eggs
	Gravel Quality (Food Productivity) (Embeddedness)	Steelhead - Summer Rearing and Winter Rearing
		Chinook - Pre Smolt, Smolts
	Gravel Quality (Food Productivity) (D 50)	Steelhead - Adults, Eggs, Summer Rearing, Winter Rearing
		Chinook - NA
Sediment Transport	Road Density	Steelhead - Watershed processes
		Chinook - Watershed Processes
	Streamside Road Density	Steelhead - Watershed processes
		Chinook - Watershed Processes
Smoltification	Temperature	Steelhead - Smolts
		Chinook - Smolts
Velocity Refuge	Floodplain Connectivity	Steelhead - Adults, Winter Rearing, Summer Adults
		Chinook - Adults, Pre Smolt, Smolts
Viability	Spatial Structure	Steelhead - Summer Rearing
		Chinook - Adults, Pre Smolt
	Density	Steelhead - Adults, Summer Rearing
		Chinook - Adults
	Abundance	Steelhead - Smolts
		Chinook - Smolts
Water Quality	Temperature (MWMT)	Steelhead - Summer Rearing
		Chinook - Pre Smolt
	Mainstem Temperature (MWMT)	Steelhead - Summer Adults
		Chinook - NA
	Turbidity	Steelhead - Adults, Summer Rearing, Winter Rearing, Smolts
		Chinook - Adults, Pre Smolt, Smolts
	Toxicity	Steelhead - Adults, Summer Rearing, Winter Rearing, Smolts, Summer Adults
		Chinook - Adults, Pre Smolt, Smolts
	Aquatic invertebrates (B-IBI NorCal, Rich, EPT)	Steelhead - Adults, Summer Rearing, Winter Rearing, Smolts (Rich only)
		Chinook - NA

Ratings are assigned to the population at a particular life stage but were based on data at various spatial scales such as reach, stream, watershed or ESU/DPS. Natural variability within and across watersheds were considered during the analysis. There are four types of indicator rating results: Poor, Fair, Good or Very Good. Natural variability was considered for all ratings.

- Very Good indicator ratings suggest high life stage survival and the habitat is fully functional to support high survival and abundance;
- Good ratings suggest high life stage survival and the habitat is functional but slightly impaired;
- Fair ratings suggest there is likely some mortality and the habitat is moderately impaired; and
- Poor ratings suggest there is high mortality and the habitat is highly impaired.

In watersheds where the majority of indicators were rated as Good or Very Good, overall conditions were likely to represent the historical range of variability and supporting transition between life stages. Conversely, where many indicators were rated as Fair or Poor overall conditions were likely to result in higher stress and mortality, making it increasingly more difficult for successful life stage transitions.

The quantitative thresholds vary by indicator and attribute type (*e.g.*, habitat condition, landscape context or population size). NMFS utilized references from the scientific literature and other sources to establish the quantitative ranges and thresholds for each of the rating categories for each indicator. In some cases, only the upward (*e.g.*, Good) and lower (*e.g.*, Poor) limits of each indicator's range were available from the scientific literature, so that Fair and Very Good rating boundaries were established via interpolation, or left undefined. Measurable quantitative indicators were used for most indicators; however, the formulation of other more qualitative decision-making structures was used when data were limited. Qualitative decision structures were used to rate three attributes: hydrology (including indicators for passage flows, redd scour, instantaneous conditions, and baseflow), estuary conditions, and toxicity.

Ratings were conducted at the watershed/population level and not at a scale smaller than a watershed or subwatershed. Ratings were informed by data at various spatial scales such as reach, stream, watershed or ESU/DPS. Natural variability within and across watersheds were considered during the analysis. The scale of data used to rate an indicator also varied by attribute type (*e.g.*, habitat condition, landscape context or population size). For example, landscape attribute data are available via GIS datasets at the watershed level (*i.e.*, population scale). Habitat condition and population size attribute data, however, are typically collected at much finer scales (*e.g.*, site, reach or stream). These data require aggregation at multiple scales to arrive at a population rating. For example, data available at the stream reach level were first aggregated to obtain a stream level rating, and then aggregated across multiple streams to attain a population or watershed level rating. Additional discussion of methods to scale data is included in sections 1.4.2 "Scaled Population Rating Strategy" and 1.4.3 "Spatial Analysis".

1.3.4 VIABILITY TABLE RESULTS

Once the conservation targets, key attributes, and indicator ratings are defined, the CAP analyst can rate the status of each attribute in a systematic way (Table 2). The results inform the analysis of current stresses and future sources of stress (threats).

Table 2. CAP example of a completed Viability Table, rating the condition of each key attribute in the watershed.

Assessment of Target Viability
Northern California Steelhead DPS ~ Bear River Population
Double-click opens entry form

#	Conservation Targets	Category	Key Attribute	Indicator	Indicator Ratings (**Bold = Current**; *Italics = Desired*): Poor	Fair	Good	Very Good	Ratings Source	Current Indicator Measurement	Current Rating	Source
1	Adults	Condition	Habitat Complexity	Large Wood Frequency (BFW 0-10 meters)	**<50% of streams/ IP-Km (>6 Key Pieces/100**	50% to 74% of streams/ IP-Km (>6 Key	75% to 90% of streams/ IP-Km (>6 Key	>90% of streams/ IP-Km (>6 Key Pieces/100	External Research	<50% of streams/ IP-km (>6 Key Pieces/100 meters)	Poor	Expert Knowledge
			Habitat Complexity	Large Wood Frequency (BFW 10-100 meters)	**<50% of streams/ IP-Km (>1.3 Key Pieces/100**	50% to 74% of streams/ IP-Km (>1.3 Key	75% to 90% of streams/ IP-Km (>1.3 Key	>90% of streams/ IP-Km (>1.3 Key Pieces/100	External Research	<50% of streams/ IP-Km (>1.3 Key Pieces/100 meters)	Poor	Rapid Assessment
			Habitat Complexity	Pool/Riffle/Flatwater Ratio	**<50% of streams/ IP-Km (>30% Pools; >20%**	50% to 74% of streams/ IP-Km (>30% Pools;	75% to 90% of streams/ IP-Km (>30% Pools;	>90% of streams/ IP-Km (>30% Pools; >20%	External Research	<50% of streams/ IP-km (>30% Pools; >20% Riffles)	Poor	Rough Guess
			Habitat Complexity	Shelter Rating	**<50% of streams/ IP-Km (>80 stream average)**	50% to 74% of streams/ IP-Km (>80 stream	75% to 90% of streams/ IP-Km (>80 stream	>90% of streams/ IP-Km (>80 stream average)	External Research	<50% of streams/ IP-km (>80 stream average)	Poor	Rough Guess
			Hydrology	Passage Flows	NMFS Flow Protocol: Risk Factor Score >75	NMFS Flow Protocol: Risk Factor Score 51-	**NMFS Flow Protocol: Risk Factor Score 35-**	NMFS Flow Protocol: Risk Factor Score <35	Expert Knowledge	NMFS Flow Protocol: Risk Factor Score 35-50	Good	Rough Guess
			Passage/Migration	Passage at Mouth or Confluence	<50% of IP-Km or <16 IP-Km accessible*	50% of IP-Km to 74% of IP-km	75% of IP-Km to 90% of IP-km	**>90% of IP-km**	Rough Guess	>90% of IP-km	Very Good	Rough Guess
			Passage/Migration	Physical Barriers	<50% of IP-Km or <16 IP-Km accessible*	50% of IP-Km to 74% of IP-km	75% of IP-Km to 90% of IP-km	**>90% of IP-km**	Expert Knowledge	100% of IP-km	Very Good	Rapid Assessment
			Riparian Vegetation	Tree Diameter (North of SF Bay)	**≤39% Class 5 & 6 across IP-km**	40 - 54% Class 5 & 6 across IP-km	55 - 69% Class 5 & 6 across IP-km	>69% Class 5 & 6 across IP-km	External Research	35.05% Class 5 & 6 across IP-km	Poor	Rapid Assessment
			Riparian Vegetation	Tree Diameter (South of SF Bay)	≤69% Density rating "D" across IP-km	70-79% Density rating "D" across IP-km	≥80% Density rating "D" across IP-km	Not Defined	External Research	N/A		
			Sediment	Quantity & Distribution of Spawning Gravels	**<50% of IP-Km or <16 IP-Km accessible***	50% of IP-Km to 74% of IP-km	75% of IP-Km to 90% of IP-km	>90% of IP-km	Expert Knowledge	<50% of IP-km or <16 IP-km accessible*	Poor	Rough Guess
			Velocity Refuge	Floodplain Connectivity	<50% Response Reach Connectivity	**50-80% Response Reach Connectivity**	>80% Response Reach Connectivity	Not Defined	Expert Knowledge	50-80% Response Reach Connectivity	Fair	Rough Guess

As noted above, the full CAP protocol and individual CAP workbooks utilized a broad suite of key attributes to assess these conditions (see Table 1 above).

1.3.5 Rapid Assessments

A simplified version of CAP, the rapid assessment, was used for selected dependent populations and independent populations not expected to attain a viable status. Although these populations are not expected to attain the low extinction risk criteria, they still contribute to meeting the connectivity criteria, and to meeting Diversity Strata level abundance targets. In general, rapid assessment analyses were less detailed and data dependent analysis than the CAP analyses. The rapid assessments utilized a subset of 12 attributes for steelhead (Table 3) and 10 for Chinook salmon (Table 4). Not all attributes were evaluated for every life stage, only those directly applicable. For example, in Table 3, Hydrology: Redd Scour was only evaluated for the egg lifestage.

Table 3. Rapid assessment example of a completed Viability Table, rating the condition of each attribute in the Diversity Stratum. Twelve attributes were rated for CCC and NC steelhead.

NC Steelhead DPS: Central Coastal Diversity Stratum (Brush/Elk/Schooner Gulch)						
TABLE 1 Habitat & Population Condition Scores By Life Stage: VG = Very Good G = Good F = Fair P = Poor		Steelhead Life History Stages				
		Adults	Eggs	Summer-Rearing Juveniles	Winter-Rearing Juveniles	Smolts
Key Attribute: Indicators	Riparian Vegetation: Composition, Cover & Tree Diameter			G		
	Estuary: Quality & Extent	G		F	G	F
	Velocity Refuge: Floodplain Connectivity	G			G	G
	Hydrology: Redd Scour		G			
	Hydrology: Baseflow & Passage Flows	G	G	F		F
	Passage/Migration: Mouth or Confluence & Physical Barriers	G		G	G	G
	Habitat Complexity: Percent Primary Pools & Pool/Riffle/Flatwater Ratios	F		F	F	
	Habitat Complexity: Large Wood & Shelter	F		P	P	F
	Sediment: Gravel Quality & Distribution of Spawning Gravels	F	F	F	F	
	Viability: Density, Abudance & Spatial Structure	F		F		F
	Water Quality: Temperature			G		G
	Water Quality: Turbidity & Toxicity	F		G	F	F

Table 4. Rapid assessment example of a completed Viability Table, rating the condition of each attribute in the Diversity Stratum. Ten attributes were rated for Chinook salmon.

CC Chinook Salmon ESU: Central Coastal Diversity Stratum (Navarro/Gualala)					
TABLE 1 Habitat & Population Condition Scores By Life Stage: VG = Very Good G = Good F = Fair P = Poor		Chinook Salmon Life History Stages			
		Adults	Eggs	Pre-Smolt	Smolts
Key Attribute: Indicators	Estuary: Quality & Extent	F		G	G
	Velocity Refuge: Floodplain Connectivity	VG		G	G
	Hydrology: Redd Scour		F		
	Hydrology: Baseflow & Passage Flows	G	G	G	G
	Passage/Migration: Mouth or Confluence & Physical Barriers	VG		VG	VG
	Habitat Complexity: Percent Primary/Staging Pools & Pool/Riffle/Flatwater Ratios	F		F	F
	Habitat Complexity: Large Wood & Shelter	F		F	F
	Sediment: Gravel Quality & Distribution of Spawning Gravels	G	F	G	G
	Viability: Density, Abudance & Spatial Structure	P		P	P
	Water Quality: Turbidity & Toxicity	G		G	G

1.3.6 STRESSES

Stresses and threats are the drivers and mechanisms leading to population decline. Stresses are defined as "the direct or indirect impairment of salmonid habitat from human or natural sources" (TNC 2007). Stresses represent altered or impaired key attributes for each population, such as impaired watershed hydrology or reduced habitat complexity. For example, the attribute for passage would become the stress of impaired passage. These altered conditions, irrespective of their sources, are expected to reduce population viability. Stresses are initially evaluated as the inverse of the key attribute rating (*e.g.*, key attributes rated as Poor may result in a stress rated as Very High or High). Ultimately the resulting stress rating is determined using two metrics, the severity of damage and scope of damage. For each population and life stage, stresses were rated using these metrics, which were combined using algorithms contained in CAP and rapid assessments to generate a single rating for each stress identified. Stresses rated Very High or High are likely sources of significant future threats and may impair recovery.

Severity of damage is the severity of the stress to the life stage that can be reasonably expected to occur over the next 10 years[2] under current circumstances.

- Very High severity scores suggest the stress will destroy or eliminate the life stage and habitats are highly impaired.
- High scores suggest high mortality and moderately impaired habitat.
- Medium scores suggest moderately degraded habitats and moderate survival of individuals at each life stage.
- Low scores suggest functional habitats and high survival.

Scope of damage is the geographic scope of the stress to the life stage that can be reasonably expected to occur over the next 10 years under current circumstances.

- Very High scores indicate the stress is likely to be pervasive or widespread in its scope and will impact all aspects of the life stage.
- High scope scores indicate the stress is likely widespread but may not impact all aspects of the life stage.
- Medium scores indicate the stress is localized in scope and may impact a few aspects of the life stage.
- Low scores indicate the stress is very localized and is not likely impacting the life stage.

Sixteen stresses were identified for the CAP analyses and rapid assessments and linked to their key attributes as shown in (Table 5). These were evaluated for specific life stages and then compared against a suite of threats described in section 1.5 "Assessing Future Conditions: Sources of Stress (Threats)". Not every indicator had an identified stress; some were grouped for the stress analysis.

Table 5. Linkages between key attributes used in the viability analysis and their altered or impaired state, identified as stresses.

Key Attribute	Stress
Estuary/Lagoon	Estuary: Quality & Extent
Habitat Complexity	Percent Primary Pools & Pool/Riffle/Flatwater Ratios (Steelhead only) Percent Primary/Staging Pools & Pool/Riffle/Flatwater Ratios (Chinook only) Large Wood & Shelter
Hydrology	Redd Scour Baseflow & Passage Flows Impervious Surfaces
Landscape Patterns	Agriculture, Timber Harvest & Urbanization
Passage/Migration	Mouth or Confluence & Physical Barriers

[2] The 10-year time period is part of the standard CAP methodology and protocol

Riparian Vegetation	Altered Riparian Species Composition & Structure
Sediment	Sediment Transport: Road Density Sediment: Gravel Quality & Distribution of Spawning Gravels
Smoltification	Water Quality: Impaired Instream Temperature
Velocity Refuge	Floodplain Connectivity
Viability	Density, Abundance & Spatial Structure
Water Quality	Temperature Turbidity or Toxicity

Stresses with a high level of severity and broad geographic scope are rated as High or Very High. For the rapid assessments, a subset of these stresses was identified and evaluated. As with CAP, the rapid assessment alogarithms combine the viability ratings of current conditions for each life stage with the stress ratings to derive a score for each stress, which is them compared against the threats. The contribution of each threat on each stress is illustrated in Table 6. As in the CAP analysis, these were evaluated for specific conservation targets (life stages) and then compared against a suite of threats.

Table 6. Example of a rapid assessment stress/threat table for CCC and NC steelhead.

NC Steelhead DPS: Central Coastal Diversity Stratum (Brush/Elk/Schooner Gulch)													
Habitat/Population/Life History Score from Table 1 →		G	F	G	G	F	G	F	P	F	F	G	F
		Stresses											
Stress-Threat Scores L = Low M = Medium H = High VH = Very High		Altered Riparian Species: Composition & Structure	Estuary: Impaired Quality & Extent	Floodplain Connectivity: Impaired Quality & Extent	Hydrology: Gravel Scouring Events	Hydrology: Impaired Water Flow	Impaired Passage & Migration	Instream Habitat Complexity: Altered Pool Complexity and/or Pool/Riffle Ratio	Instream Habitat Complexity: Reduced Large Wood and/or Shelter	Instream Substrate/Food Productivity: Impaired Gravel Quality & Quantity	Reduced Density, Abundance & Diversity	Water Quality: Impaired Instream Temperatures	Water Quality: Increased Turbidity or Toxicity
Threats - Sources of Stress	Agriculture	M	M	M	M		L	M	M	H		M	M
	Channel Modification	M	M	M	M	M	M	M	M	M		M	M
	Disease, Predation, and Competition	M	M	M			M	M	M		M	M	M
	Fire, Fuel Management, and Fire Suppression	M	M	L	M		M	M	H	H		M	H
	Livestock Farming and Ranching	M	L	M	L		L	M	L	M		M	M
	Logging and Wood Harvesting	H	M	M	H		L	H	H	H		H	H
	Mining	L	L	L	L		L	L	L	L		L	L
	Recreational Areas and Activities	M	M	M	M		M	M	M	M		M	M
	Residential and Commercial Development	M	M	M	M		L	M	M	M		M	M
	Roads and Railroads	H	M	H	H		M	M	M	H		M	H
	Severe Weather Patterns	M	M	M	M	H	M	M	M	H		H	H
	Water Diversions and Impoundments	M	VH	M	L	H	H	H	M	H	H		
	Fishing and Collecting										VH		
	Hatcheries and Aquaculture										L	L	L

1.4 ASSESSING CONDITIONS: KEY ATTRIBUTES AND STRESSES

This section describes all key attributes, their indicators, and ratings used in the CAP analyses and rapid assessments, and describes methods used to inform those ratings. As discussed above, stresses were identified as altered or impaired key attributes, and then compared against a suite of threats.

1.4.1 DATA ANALYSIS AND DATA SOURCES

The data that informed our analyses came from a wide variety of sources. Sources included the California Department of Fish and Wildlife (CDFW), the State Water Resources Control Board (SWRCB) the U.S. Environmental Protection Agency (USEPA), Resource Conservation Districts (RCDs), other state and federal entities, water agencies, private timber companies, conservation organizations, consultants, local watershed groups and others. In particular, CDFW provided extensive habitat typing data for most of the essential or supporting populations. Some data required additional evaluation, analysis and synthesis. To provide support for data acquisition, NMFS contracted with the Sonoma Ecology Center (SEC) to search for, compile, manage, and apply the disparate data needed to inform many of the indicators and ratings.

NMFS' GIS unit provided extensive information and analysis, particularly for land use attributes. For each essential or supporting watershed, an individual report was developed with detailed information on a variety of indicators. These "watershed characterizations" detailed acreage and percentage of urbanization, land ownership, land cover, current and projected development, road densities, erosion potential, amount of farmland, timber harvesting history, location and types of barriers, diversions, and industrial influences (mines, discharge sites, toxic release sites) and stream temperature. These data were utilized either to directly inform the CAP and rapid assessment ratings or to inform the Recovery Team's general watershed knowledge.

Because data were collected using a variety of protocols, many of the indicators required its own method of integrating data. The methods are briefly summarized into the following categories:

1. CDFW Stream Survey Data (Hab-8)[3]: NMFS secured all available CDFW reach level habitat typing data (Hab-8) data for the NCCC Domain. The CDFW habitat typing procedure is a standardized methodology that physically classifies 100 percent of the wetted channel by habitat type from the mouth to the end of

[3] Methods for Hab-8 surveys are described in Flosi *et al*. (2004).

anadromy (Flosi *et al*. 2004). The methodology is utilized in wadeable streams (stream orders 1-4). CDFW follows a random sampling protocol stratified by stream reach (*i.e.*, Rosgen Channel type) to measure conditions within habitat types, for variables such as depth, for example. Typically, depth is recorded in approximately every third habitat unit in addition to every fully-described unit which provides an approximate 30% sub-sample for all habitat units. Thus, habitat data can be utilized to characterize each reach of stream, and data can be averaged over the collection of reaches to characterize the stream. These datasets were standardized into an Access database under funds provided by SCWA. This *Stream Summary Application* (Appendix E) was developed by University of California Hopland Research & Extension Center (HREC) and CDFW. Seven indicators were informed by the CDFW stream habitat-typing dataset (Pool/Riffle/Flatwater Ratio, Canopy Cover, Large Woody Debris, Shelter Rating, Embeddedness, and Percent Primary and Staging Pools). These data provided coverage across 18 of 34 essential or supporting steelhead populations and all 10 essential or supporting Chinook populations. The data is stored in the *Stream Summary Application* (Appendix E).

2. Stream Flow: Lack of sufficient gage data in rearing and migration habitats led us to derive ratings for instream flow indicators from a structured decision-making model informed by a panel of local experts (see below for the complete protocol). Four indicators (Baseflow, Instantaneous Condition, Passage Flows, and Redd Scour) were developed with this method. The Number of Diversions was calculated by SWRCB data sets.
3. Instream Temperature Data: Three indicators (Maximum Weekly Maximum Temperature (MWMT), Mainstem Temperature, and Smoltification) were used to inform this habitat attribute, but it required extensive compilation of disparate datasets. Temperature data was grouped into condition classes when multiple location information was available and extrapolated to inform a watershed-wide rating. Final ratings were made by estimating the proportion of a watershed's Intrinsic Potential (IP) habitat (habitat historically supporting the species)[4] that fell within each temperature class.
4. Water Quality (Turbidity and Toxicity) Data: The indicator for turbidity was difficult to quantify, so ratings were informed by an assessment of the erosion potential developed by the California Department of Conservation, Division of Mines and Geology, literature review and expert opinion. A structured decision making model was used to rate toxicity.
5. Estuary Conditions: Multiple factors were considered for open and closed estuaries and lagoons using a structured protocol informed by a panel of NMFS staff familiar with individual estuaries to provide an overall rating of estuary

[4] The extent of habitat historically supporting the species was developed using a model that considered mean annual discharge, valley width, gradient, and for coho salmon (which are not included in this recovery plan), temperature. See Spence *et al*. (2008) for details.

quality and extent. Factors included historic extent, current configuration and alteration to physical extent, as well as other physical, chemical and biological parameters to describe estuary condition for rearing, and smolt salmonids. The complete protocol is included below in section 1.4.5, Estuary/Lagoon: Quality & Extent.

6. Spatial Datasets: Several indicators (Impervious Surface, Agriculture, Timber Harvest, Urbanization, Species Composition, Road Density, and Streamside Road Density) were informed by GIS queries of available spatial datasets.
7. Population Viability: Three viability indicators (abundance, density, and spatial structure) were informed by review and synthesis of all available fisheries monitoring data in the ESU/DPS.
8. Other Indicators: The remaining indicators (Passage at Mouth or confluence, Physical Barriers, V* Star[5], Tree Diameter, Quantity & Distribution of Spawning Gravels, and Aquatic Invertebrates) were informed by various methods ranging from queries of existing databases (*e.g.*, physical barriers) to best professional judgment (*e.g.*, passage at mouth or confluence). For example, physical barriers were assessed using the Pacific States Marine Fisheries Council Passage Assessment Database (PAD) (PSMFC 2014). The indicator for passage at mouth or confluence was assessed by NMFS staff with local knowledge of the watershed conditions.
9. The indicators of V*Star, D 50[6], and aquatic invertebrates were used to evaluate conditions in populations which overlapped analyses conducted for the Southern Oregon Northern California Coho (SONCC) salmon Recovery Plan.

Additional information was gathered by reviewing watershed assessment documents and strategic planning materials from local/state/Federal agencies, contacting knowledgeable individuals, utilizing staff expertise, and consulting a number of other references.

Contributions from NMFS Contractors

To provide focused support for data acquisition, NMFS North Central Coast Office (NCCO) contracted with the Sonoma Ecology Center (SEC) to search for, compile, manage, and apply the disparate data necessary to inform many of the indicators and ratings for the CCC and NC steelhead, and CC Chinook populations. The NMFS Northern California Office (NCO) contracted with Kier Associates to compile, manage, and process CAP workbook output for NC steelhead and CC Chinook Populations. NC steelhead and CC Chinook population CAP workbooks, profiles and recovery actions were compiled by both offices according to geographic boundaries and responsibility.

[5] V* is a measure of the supply of excess fine sediment (sand and fine gravel) in gravel bed channels (http://www.fs.fed.us/psw/topics/water/vstar/).

[6] D 50 median particle size in a streambed (*i.e.*, 50% of the particles in the sediment bed sample are finer than the D 50 particle size) (Lisle 1995).

All CCC steelhead population CAP workbooks, profiles and strategies and most chapters were compiled/authored by NMFS NCCO. Finally, the NMFS GIS unit provided extensive support in spatial analysis and mapping.

Much of SEC's effort involved the application of the available CDFW Hab-8 data to 18 of 44 essential or supporting steelhead and all 10 essential or supporting Chinook salmon. SEC managed data acquisition (from CDFW), spatially referenced the data, conducted bias analyses and quality control, as well as developed the necessary queries to match the data to 14 of the 36 CCC steelhead, 48 NC steelhead and 42 CC Chinook indicators. SEC supported assessments of passage issues using the Pacific States Marine Fisheries Council Passage Assessment Database (PSMFC 2014). They also used the National Land Cover Database[7] to calculate the percent of impervious surface and percent of land in agriculture for 28 watersheds. Finally, SEC conducted exploratory data searches for several indicators to investigate the feasibility of using data-driven ratings for a number of indicators related to diversions, instream flows, estuaries, and toxicity. Due to lack of data, in most of these cases we reverted to using structured decision-making. However, SEC supported the process and output models with the best available data.

Kier and Associates compiled data for NC steelhead populations which were also utilized in the development of the SONCC Recovery Plan, for use by NMFS NCO analysts. Kier and Associates also processed new data, complied references for each population, and ran GIS analysis for some NC steelhead populations. Finally, Kier and Associates also developed specialized Excel spreadsheets to hold document data and references, which expedited processing of CAP workbook data for NMFS NCO and NCCO offices, and processed CAP workbook output for all NCO NC steelhead populations.

1.4.2 Scaled Population Rating Strategy

A scaled population rating strategy was developed for use in the CAP analyses. Since the rapid assessments were conducted at a larger Diversity Strata scale, this was not applicable to those assessments. The intrinsic potential model used criteria for stream gradient, valley width, and mean annual discharge, to provide quantitative estimates of potential habitat for each population in kilometers (km), with qualitative estimates of the intrinsic potential (IP) weighted (between 0 and 1). These values provided an estimate of the value of each km segment for each species (coho salmon, Chinook salmon, and steelhead) inhabiting a particular watershed. Historical and current IP km estimates were used to determine historical and current population abundance targets. Known migration barriers were evaluated against the modeled IP. In some cases the IP extent was modified based on natural barriers not captured by the model, current conditions,

[7] http://www.mrlc.gov/nlcd2001.php

and likely irretrievability of some stream reaches to achieve properly functioning conditions.

Scaled population ratings were based on the relevant contribution each site, reach, and stream makes to the population as a whole. Where data were collected at finer scales, data were aggregated up to arrive at a single rating for a given population. A typical rating scenario involved two to three steps; 1) a rating at the site or reach level, 2) rating at the stream level, and 3) a rating at the population (watershed) level, which aggregated multiple stream ratings. Reach and stream level ratings were incorporated into the CAP analysis for each population.

CDFW stream habitat-typing data (Hab-8 data) informed many of the attribute indicators in the CAP Workbook. Data from multiple stream reaches were aggregated to rate each stream based on the criteria for each indicator, and its ability to support a particular life stage or stages. As an example, CDFW considers a primary pool frequency of 50 percent desirable for salmonids (Bleier *et al.* 2003). Primary pool frequency varies by channel depth and stream order[8] therefore, to extrapolate reach scale data upward to the stream scale, rating criteria were established which used a 25 percent boundary from the 50 percent threshold to describe Good conditions (*i.e*. the indicator was within acceptable range of variation). Criteria for Poor, Fair and Very Good ratings followed the same procedure to establish numeric boundaries for each qualitative category at the stream level scale:

Stream level percent primary pool
Poor = < 25% primary pools;
Fair = 25% to 49% primary pools;
Good = 50% to 74% primary pools; and
Very Good = ≥ 75% primary pools.

Because ratings were ultimately applied at the watershed or population scale, and a population could include multiple streams, stream level ratings were aggregated to obtain a population level rating, and characterize the contribution of each stream/watershed to the population. Good conditions were defined as the level which described an acceptable limit of the variation inherent to each indicator constituting the minimum conditions for persistence of the target. If the indicator measurement lies below this acceptable range, it was considered to be in degraded condition. Specifically, a Good stream rating was considered the minimum value necessary to complete life stage function and transition. However, stream attributes are unlikely to meet good conditions across 100 percent of a watershed/population, given the natural variability in geomorphic variables such as reach type, stream order, stream width and gradient,

[8] Stream order is a hierarchal measure of stream size. First order streams drain into second order streams, and so on. The presence of higher order streams suggests a larger, more complex watershed.

hydrologic variables such as rainfall, biologic factors such as vegetation, and the varying degree of natural disturbances such as fire, flood or drought. To account for natural variation at the population scale, quartile ranges (< 50%, 50-74%, 75-90%, > 90%) were used for population level ratings to extrapolate stream level data upward to the population scale:

Population level percent primary pool rating criteria
Poor = < 50% of streams/IP km rating good or better;
Fair = 50% to 74% of streams/IP km rating good or better;
Good = 75% to 90% of streams/IP km rating good or better; and
Very Good = > 90% of streams/IP km rating good or better.

Represented schematically, Figure 3 illustrates this stepwise aggregation of data to arrive at a watershed level rating for each attribute.

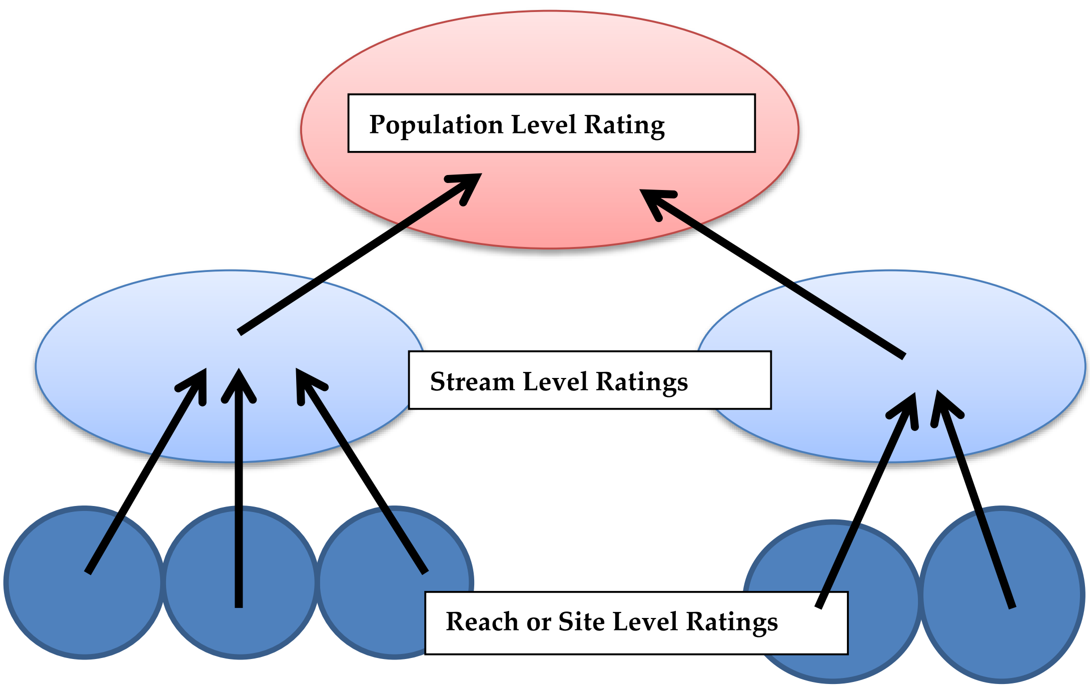

Figure 3. Schematic representation of stepwise aggregation of data, beginning with site or reach specific data, to arrive at a single population or watershed level attribute rating.

In situations where the percent-of-streams metric deviated from the percent IP km metric or where the rating criteria is not consistent (*e.g.*, Poor vs. Good in different streams within the same watershed), the percent IP km rating criteria was used as the default. In these cases, map based (GIS and Google Earth) analysis tools were used to visually evaluate each stream's contribution to the universe of good quality habitat for each population. Where quantitative measurements were lacking, a qualitative estimate was used based on best available literature, spatial data and IP km extent and value. Population level ratings are presented within each population profile (see Volumes II, III, and IV) to summarize conditions and for comparative purposes across the ESU/DPS.

NMFS GIS staff mapped IP km extent and value utilizing Google Earth (.kml files) to provide spatial representation of the historical intrinsic potential for various data layers and analysis. These data were used in combination with the Hab-8 layer (#4 below), to compare the current condition of a given habitat segment to its historical expectation/performance/contribution. The following methods were used:

1. IP extent and value per Calwater/sub-watershed unit GIS map for each recovery population/watershed provided spatial representation of each streams/sub-watersheds highest percentage IP km values. IP km valued habitats were color coded within each Calwater/sub-watershed unit;
2. IP numeric extent and value per Calwater/sub-watershed unit Excel spreadsheet for each recovery population/watershed provided the numeric information corresponding to the Calwater/sub-watershed highest percentage maps. This spreadsheet included a breakdown of the ratio of IP km valued habitat within each Calwater/sub-watershed unit; the extent (km) of each IP km valued habitat within each Calwater/sub-watershed unit; and the total (km) of IP km valued habitat within a given Calwater/sub-watershed unit;
3. CDFW surveyed reaches (Hab-8 data) were overlaid on Google Earth providing spatial representation of the extent of Hab-8 data. This was utilized in combination with the IP km layer (#1 above) to aid the analyst in making a determination of the extent in which a given population's IP-modeled habitat had been surveyed; and
4. Reach scale Hab-8 survey extent were overlaid with IP km modeled habitat on maps to evaluate discrepancies between percent of stream and percent of IP km rating criteria for a particular indicator. Maps also displayed IP km modeled habitat color coded by value (high, medium, low) and specific Hab-8 surveyed reach locations.

1.4.4 CONFIDENCE RATINGS

The assessment of watershed conditions for the indicators defined below relied heavily on CDFW's stream habitat-typing data (Hab-8 data). While this data provided the best available coverage throughout the NCCC Domain, it did not cover all IP km or all watersheds, and in some cases covered only small portions of a watershed.

We analyzed the variable coverage of Hab-8 data across watersheds to measure the confidence in our conclusions at the population scale. Two measures were investigated: 1) the percent of IP km covered by Hab-8 surveys, and 2) the relative distribution of IP km values within the surveyed areas compared to the population as a whole.

The percent of IP km covered gave a measure of sample size. For example, confidence might be low if less than 20 percent of all IP km in the population were surveyed, which could be significant if this indicator alone characterized the population as a whole. Table 7 shows the level of confidence as a function of increased coverage.

Table 7. Confidence ratings for Hab-8 data as a function of percent of IP km surveyed.

Confidence	Low	Fair	High	Very High
% Coverage	< 20	20-49	50-79	≥ 80

To determine whether surveyed areas were representative of habitat throughout the population, the distribution of IP km values (between 0 and 1) were compared within the surveyed reaches to the overall distribution of IP km values in the population. For both surveyed reaches and overall IP km, the average IP km value and standard deviation (SD) were calculated. The Albion River population for example, had an average IP km value of 0.58 (SD 0.28). This Albion River comparison provides a relative indication of total surveyed areas compared to other watersheds (*e.g.*, 0.71 (SD 0.39)).

1.4.5 ESTUARY/LAGOON: QUALITY & EXTENT

Steelhead Target: Summer Rearing, Smolts
Chinook Target: Adults, Pre-Smolt, Smolts

Estuaries and lagoons provide important habitat for adults, rearing salmonids and smolts that undergo physiological transitions as they prepare to enter the ocean (smoltification).

Many estuaries and lagoons across the NCCC Domain have been degraded by management actions such as channelization, artificial breaching, and encroachment of infrastructure such as highways, bridges, residential and commercial development, and sediment deposition. These and other anthropogenic effects have reduced estuary and lagoon habitat quality and extent.

Methods:

Because data were lacking in many populations a qualitative decision structure was developed to derive ratings for the estuary/lagoon indicator. The protocol provided a structured process to capture and evaluate diverse types of data where it was available, and to apply qualitative assessments where data were lacking. It included three major components:

- General rating parameters applied to all estuaries and lagoons to evaluate the current extent and adverse alterations to the river mouth, hydrodynamics (wetland and freshwater inflow), and artificial breaching. In addition, the protocol for CAPs included alterations to the inner estuary/lagoon wetlands, and where data were available, consideration of additional parameters;

- Rating parameter timelines for estuaries functioning or managed as open systems were March 15 to November 15 (to include the pre-smolt timing of the summer rearing period); and
- Rating parameter timelines for lagoons currently functioning or managed as closed systems were March 15 to November 15 (to include the pre-smolt timing of the summer rearing period).

An abbreviated version of the full protocol was used in rapid assessments. Both protocols are described in detail below.

CAP Parameters to Consider When Rating Estuaries and Lagoons

1. <u>General Rating Parameters for Estuaries and Lagoons</u>

Criteria	Population Name	Confidence/Source
1. Current Extent: Fraction of the Estuary/Lagoon in Natural Conditions		
2. Alteration to River Mouth Dynamics (Estuary Opening Patterns)		
3. Alterations to Hydrodynamics: Inner Estuary/Lagoon Wetlands		
4. Frequency of Artificial Breaching (Seasonal)		
5. Alterations to Freshwater Inflow (refer to Instream Flow Protocol)		
Overall rating		

a. Current Extent: Fraction of the estuary and/or lagoon in natural conditions (prior to European settlement); including tracts of salt and freshwater marshes, sloughs, tidal channels, including all other tidal and lagoon inundated areas:

Very Good	Good	Fair	Poor
≥ 95%	95-67%	66-33%	< 33%

b. Alteration to river mouth dynamics leading to changes in estuary opening patterns due to jetties, tide gates, roads/railroads, bridge abutments, dredging, and artificial breaching, *etc.*:

Very Good	Good	Fair	Poor
No modification	Slight modification to estuary entrance, but still properly functioning	Some modification altering the estuary entrance from naturally functioning	Major modification restricting the estuary entrance from properly functioning

c. **Alterations to *INNER* estuary/lagoon hydrodynamics (upstream of the river mouth) due to construction of barriers (dikes, culverts, tide gates, roads/railroads, *etc*.):**

Very Good	Good	Fair	Poor
No impairments	Some impairments; 95-67% of the estuary/lagoon remains hydrologically connected	Impairments, but 66-33% of the estuary/lagoon remains hydrologically connected	Extensive impairments, with <33% of the estuary/lagoon hydrologically connected

d. **Frequency of artificial breaching events:**

Very Good	Good	Fair	Poor
No artificial breaching occurs: natural variability	<1 artificial breaching event immediately following a rain event; no artificial breaching during the rearing season (March 15 – November 15)	Artificial breaching events only occur prior to significant storm events	Winter and summer breaching events independent of rain events

e. **Alterations to freshwater inflow (refer to Instream Flow Protocol for guidance):**

Very Good	Good	Fair	Poor
No impoundments within the watershed	Total impoundment volume <20% median annual flow	Total impoundment volume 20-50% median annual flow	Total impoundment volume 51-100% median annual flow

2. **<u>Rating Parameters for Estuaries Currently Functioning or Managed as an Open System (*Rearing Season: March 15 – November 15)</u>**
***Includes the pre-smolt timing of the summer rearing period.**

Criteria	Population Name	Confidence/Source
Tidal Prism: Estuarine Habitat Zones		
Tidal Range (Flushing Rate)		
Temperature (C): Estuarine		

Habitat Zones		
Dissolved Oxygen (mg/L): Estuarine Habitat Zones		
Macro-Invertebrates Abundance and Taxa Richness: Estuarine Habitat Zones		
Habitat Elements and Complexity		
Toxicity (Metal, Pesticides, Pollution, *etc*.)		
Exotic Pest Species		
Overall rating		

a. **Estuarine Habitats Zones: Marine salinity zone (33 to 18 ppt); mixing/transitional zone (18 to 5 ppt); and riverine/freshwater tidal zone (5 to 0 ppt):**

Very Good	Good	Fair	Poor
All zones are present and are relatively equal in total area - natural tidal prism (33.3% ea.)	Any approximate percentage ratio with a 40/40/20 combination (example: 20% MSZ; 40% MZ; 40% RTZ)	Any approximate percentage ratio with a 45/45/10 combination	Any approximate percentage ratio with <10% of any one zone represented

b. **Tidal Range (flushing rate):**

Very Good	Good	Fair	Poor
Estuary reach very well flushed (macro-tidal); excellent vertical mixing	Estuary reach moderately well flushed (meso-tidal); good vertical mixing	Estuary reach is moderately flushed (micro-tidal); some vertical mixing occurs, but some areas remain stagnant (not mixed or flushed)	Estuary reach very poorly flushed (ultra micro-tidal); poor vertical mixing resulting in reduced water quality (low DO)

c. **Relative temperature within each Estuarine Habitat Zones (marine salinity zone, mixing/transitional zone, and riverine tidal zone):**

i. **Temperature: Marine Salinity Zone (33 to 18 ppt) -** Immediately inside the mouth of the estuary to the start of the mixing/transitional zone:

Very Good	Good	Fair	Poor
≤ 14.0° C	14.1-16.5° C	16.6-18.0° C	> 18.0° C

ii. **Temperature: Mixing/Transitional Zone (18 – 5 ppt) –** Area where the salinity within the Estuarine Habitat Zone ranges from 18 to 5 ppt:

Very Good	Good	Fair	Poor
≤16.0° C	16.1°-18.0° C	18.1°-20.0° C	> 20.0° C

iii. **Temperature: Riverine or Freshwater Tidal Zone (<5 ppt) –** Area from the mixing/transitional zone to the head-of-tide:

Very Good	Good	Fair	Poor
≤ 17° C	17.1°-19.0° C	19.1°-21.5° C	> 21.5° C

d. **Relative Dissolved Oxygen (mg/L) for a given duration within each Estuarine Habitat Zones (marine salinity zone, mixing/transitional zone, and riverine tidal zone):**

i. **Dissolved Oxygen (mg/L): Marine Salinity Zone -** Immediately inside the mouth of the estuary to the beginning of the mixing/transitional zone:

Very Good	Good	Fair	Poor
≥7.75 mg/L at all times	7.74-6.5 mg/L at all times	Fall below 6.5 mg/L, but stays above or equal to 5.0 mg/L for < 24hrs	Falls below 5.0 mg/L for periods > 24 hours

ii. **Dissolved Oxygen (mg/L): Mixing/Transitional Zone –** Area where the Estuarine Habitat Zone ranges from 18 to 5 ppt:

Very Good	Good	Fair	Poor
≥7.75 mg/L at all times	7.74-6.5 mg/L at all times	Fall below 6.5 mg/L, but stays above or equal to 5.0 mg/L for < 24hrs	Falls below 5.0 mg/L for periods > 24 hours

iii. **Dissolved Oxygen (mg/L): Riverine or Freshwater Tidal Zone –** Area from the mixing/transitional zone to the head-of-tide:

Very Good	Good	Fair	Poor
≥ 7.75 mg/L at all	7.74-6.5 mg/L at all	Fall below 6.5 mg/L,	Falls below 5.0

times	times	but stays above or equal to 5.0 mg/L for < 24hrs	mg/L for periods > 24 hours

e. **Relative Macro- Invertebrate Abundance and Taxa Richness within each Estuary Habitat Zone –** Macro-invertebrates that are known or would be considered to be available prey items for juvenile salmonids:

i. **Relative Macro- Invertebrate Abundance and Taxa Richness: Marine Salinity Zone -** Immediately inside the mouth of the estuary to the start of the mixing zone:

Very Good	Good	Fair	Poor
Abundance and taxa richness are considered to be high	Abundance of prey items is high, but taxa richness is relatively low	Abundance is of prey items and/or taxa richness are moderate	Abundance of prey items and/or taxa richness are low

ii. **Relative Macro- Invertebrate Abundance and Taxa Richness Mixing/Transitional Zone –** Area where the salinity zone ranges from 18 to 5 ppt:

Very Good	Good	Fair	Poor
Abundance and taxa richness are considered to be high	Abundance of prey items is high, but taxa richness is relatively low	Abundance is of prey items and/or taxa richness are moderate	Abundance of prey items and/or taxa richness is low

iii. **Relative Macro- Invertebrate Abundance and Taxa Richness: Riverine or Freshwater Tidal Zone –** Area from the mixing/transitional zone to the head-of-tide**:**

Very Good	Good	Fair	Poor
Abundance and taxa richness are considered to be high	Abundance of prey items is high, but taxa richness is relatively low	Abundance is of prey items and/or taxa richness are moderate	Abundance of prey items and/or taxa richness is low

f. **Habitat Elements and Complexity -** % area containing SAV, large or small WD, emergent and/or riparian vegetation, marshes, sloughs, tidal wetlands, pools > 2 meters, *etc.*:

Very Good	Good	Fair	Poor

> 70%	69-45%	44-20%	<20%

g. **Toxicity - Toxicity -** % of area where containments are detected (metals, pesticides, and pollution that are impacting the estuary ecosystem, *etc*.):

Very Good	Good	Fair	Poor
Not detected	< 2%	2.1-5%	> 5%

h. **Exotic Pest Species -** Number of exotic pest species that alter the estuary ecosystem and significantly impact salmonids (please note how exotic pest species impacts salmonids - *i.e*., stripers - predation):

Very Good	Good	Fair	Poor
No exotic pest species known to be present	One or more pest species present but there are **no major** impacts to salmonids and the estuary ecosystem	One or more pest species present and at least one is having a **moderate** impact to salmonids and the estuary ecosystem	One or more pest species present and at least one is having a **major** impact to salmonids and the estuary ecosystem

i. **Quantity of Rearing Habitat (Life Stage and Species) = OVERALL**

a. **Quantity of rearing habitat for young-of-year salmonids and/or *NON-osmoregulating* salmonids (refer to rating 1a listed above for guidance – Estuarine Habitat Zones, water quality parameters, etc.):**

Very Good	Good	Fair	Poor
≥ 95%	94-67%	66-33%	< 33%

b. **Quantity of rearing habitat for osmoregulating salmonids (refer to rating 1a listed above for guidance – Estuarine Habitat Zones, water quality parameters, *etc*.):**

Very Good	Good	Fair	Poor
≥ 95%	94-67%	66-33%	< 33%

3. **<u>Rating Parameters for Estuaries Currently Functioning or Managed as a Closed System (*Rearing Season: March 15 – November 15)</u>**
***Includes the pre-smolt timing of the summer rearing period.**

Criteria	Population Name	Confidence/Source

Seasonal Closure (date/month)		
Freshwater Conversion (d)		
Lagoon Elevation – NGVD (ft.)		
Temperature (C): Lagoon Habitat Zones		
Dissolved Oxygen (mg/L): Lagoon Habitat Zones		
Macro-Invertebrates Abundance and Taxa Richness: Lagoon Habitat Zones		
Habitat Elements and Complexity		
Toxicity (Metal, Pesticides, Pollution, etc.)		
Exotic Pest Species		
Overall rating		

a. **Seasonal Closure –** Timing of sandbar formation creating a summer rearing lagoon (date/month):

Very Good	Good	Fair	Poor
April 15 – May 6	May 7 – May 31	June 1 – June 21	Later than June 21st

b. **Freshwater Conversion –** number of days required to complete freshwater transformation:

Very Good	Good	Fair	Poor
1 to 3	3 to 7	7 to 14	>14

c. **Freshwater Lagoon Elevation during seasonal closure (NGVD):**

Very Good	Good	Fair	Poor
> 5 feet	> 4 feet	> 3 feet	< 3 feet

d. **Relative temperature within each Lagoon Habitat Zone (Lower, Middle, Upper):**

   i. **Temperature: Lower Lagoon Habitat Zone -** Immediately inside the sandbar to approximately the middle reach of the lagoon:

Very Good	Good	Fair	Poor
< 16.0° C	16.1°-18.0° C	18.1°-20.0° C	> 20.0° C

ii. Temperature: Middle Lagoon Habitat Zone:

Very Good	Good	Fair	Poor
< 17° C	17.1°-19.0° C	19.1°-21.5° C	> 21.5° C

iii. Temperature: Upper Lagoon Habitat Zone:

Very Good	Good	Fair	Poor
< 17° C	17.1°-19.0° C	19.1°-21.5° C	> 21.5° C

e. Relative Dissolved Oxygen (mg/L) for a given duration within each of the Lagoon Habitat Zones (Lower, Middle, Upper):

i. Dissolved Oxygen (mg/L): Lower Lagoon Habitat Zone - Immediately inside the mouth of the estuary to the start of the mixing/transitional zone:

Very Good	Good	Fair	Poor
> 7.75 mg/L at all times	7.74-6.5 mg/L at all times	Fall below 6.5 mg/L, but stays above or equal to 5.0 mg/L for <24hrs	Falls below 5.0 mg/L for periods > 24 hours

ii. Dissolved Oxygen (mg/L): Middle Habitat Zone:

Very Good	Good	Fair	Poor
> 7.75 mg/L at all times	7.74-6.5 mg/L at all times	Fall below 6.5 mg/L, but stays above or equal to 5.0 mg/L for < 24hrs	Falls below 5.0 mg/L for periods > 24 hours

iii. Dissolved Oxygen (mg/L): Upper Lagoon Habitat Zone:

Very Good	Good	Fair	Poor
> 7.75 mg/L at all times	7.74-6.5 mg/L at all times	Fall below 6.5 mg/L, but stays above or equal to 5.0 mg/L for < 24hrs	Falls below 5.0 mg/L for periods > 24 hours

f. **Relative Macro- Invertebrate Abundance and Taxa Richness within each Lagoon Habitat Zone –** Macro-invertebrates that are known or would be considered to be available prey items for juvenile salmonids:

i. **Relative Macro- Invertebrate Abundance and Taxa Richness: Lower Lagoon Habitat Zone:**

Very Good	Good	Fair	Poor
Abundance and taxa richness are considered to be high	Abundance of prey items is high, but taxa richness is relatively low	Abundance is of prey items and/or taxa richness are moderate	Abundance of prey items and/or taxa richness are low

ii. **Relative Macro- Invertebrate Abundance and Taxa Richness: Middle Lagoon Habitat Zone:**

Very Good	Good	Fair	Poor
Abundance and taxa richness are considered to be high	Abundance of prey items is high, but taxa richness is relatively low	Abundance is of prey items and/or taxa richness are moderate	Abundance of prey items and/or taxa richness is low

iii. **Relative Macro- Invertebrate Abundance and Taxa Richness: Upper Lagoon Habitat Zone:**

Very Good	Good	Fair	Poor
Abundance and taxa richness are considered to be high	Abundance of prey items is high, but taxa richness is relatively low	Abundance is of prey items and/or taxa richness are moderate	Abundance of prey items and/or taxa richness is low

g. **Habitat Elements and Complexity -** % area containing SAV, large or small WD, emergent and/or riparian vegetation, marshes, sloughs, tidal wetlands, pools > 2 meters, etc.:

Very Good	Good	Fair	Poor
> 70%	70-45%	44-20%	< 20%

h. **Toxicity -** % of area where containments are detected (metals, pesticides, and pollution that are impacting the estuary ecosystem, etc.):

Very Good	Good	Fair	Poor
Not detected	< 2%	2.1-5%	> 5%

i. **Exotic Pest Species -** Number of exotic pest species that alter the estuary ecosystem and significantly impact salmonids (analyst should note how exotic pest species impacts salmonids - *i.e.*, stripers - predation):

Very Good	Good	Fair	Poor
No exotic pest species known to be present	One or more pest species present but there are **no major** impacts to salmonids and the estuary ecosystem	One or more pest species present and at least one is having a **moderate** impact to salmonids and the estuary ecosystem	One or more pest species present and at least one is having a **major** impact to salmonids and the estuary ecosystem

j. **Quantity of Rearing Habitat (Life Stage and Species) = OVERALL**

   i. **Quantity of rearing habitat for young-of-year salmonids and/or *NON-osmoregulating* salmonids (refer to rating 1a listed above for guidance – Lagoon Habitat Zones, water quality parameters, *etc*.):**

Very Good	Good	Fair	Poor
>95%	95-67%	66-33%	< 33%

   ii. **Quantity of rearing habitat for osmoregulating salmonids (refer to rating 1a listed above for guidance – Lagoon Habitat Zones, water quality parameters, *etc*.):**

Very Good	Good	Fair	Poor
> 95%	95-67%	66-33%	< 33%

<u>Rapid Assessment Parameters to Consider When Rating Estuaries and Lagoons</u>

1. **Current Extent: Fraction of the estuary and/or lagoon in natural conditions (prior to European settlement); including tracts of salt and freshwater marshes, sloughs, tidal channels, including all other tidal and lagoon inundated areas:**

Very Good	Good	Fair	Poor
> 95%	95-67%	66-33%	< 33%

2. **Alteration to river mouth dynamics leading to changes in estuary opening patterns due to jetties, tide gates, roads/railroads, bridge abutments, dredging, and artificial breaching, *etc*.:**

Very Good	Good	Fair	Poor
No modification	Slight modification to estuary entrance, but still properly functioning	Some modification altering the estuary entrance from naturally functioning	Major modification restricting the estuary entrance from properly functioning

3. **Alterations to freshwater inflow:**

Very Good	Good	Fair	Poor
No impoundments within the watershed	Total impoundment volume <20% median annual flow	Total impoundment volume 20-50% median annual flow	Total impoundment volume 51-100% median annual flow

4. **Frequency of artificial breaching events:**

Very Good	Good	Fair	Poor
No artificial breaching occurs: natural variability	<1 artificial breaching event immediately following a rain event; no artificial breaching during the rearing season (March 15 – November 15)	Artificial breaching events only occur prior to significant storm events	Winter and summer breaching events independent of rain events

5. **Habitat Elements and Complexity -** % area containing SAV, large or small WD, emergent and/or riparian vegetation, marshes, sloughs, tidal wetlands, pools > 2 meters, etc.:

Very Good	Good	Fair	Poor
> 70%	70-45%	45-20%	< 20%

a. **Temperature: Mixing/Transitional Zone (18 – 5 ppt) –** Area where the salinity within the Estuarine Habitat Zone ranges from 18 to 5 ppt:

Very Good	Good	Fair	Poor
< 16.0° C	16.1°-18.0° C	18.1°-20.0° C	> 20.0° C

b. **Temperature: Riverine or Freshwater Tidal Zone (<5 ppt) –** Area from the mixing/transitional zone to the head-of-tide:

Very Good	Good	Fair	Poor
< 17° C	17.1°-19.0° C	19.1°-21.5° C	> 21.5° C

6. Relative Dissolved Oxygen (mg/L) for a given duration within each Estuarine Habitat Zones (marine salinity zone, mixing/transitional zone, and riverine tidal zone):

Very Good	Good	Fair	Poor
>7.75 mg/L at all times	7.74-6.5 mg/L at all times	Fall below 6.4 mg/L, but stays above or equal to 5.0 mg/L for < 24hrs	Falls below 5.0 mg/L for periods > 24 hours

Ratings:
The estuary protocol assessed a variety of components of estuary/lagoon habitat using a qualitative decision structure. Rating thresholds were defined in the following manner:

Poor = Impaired/nonfunctional;
Fair = Impaired but functioning;
Good = Properly functioning conditions; and
Very good = Unimpaired conditions.

Stress:
The stress for this attribute was Estuary: Quality & Extent, and it was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect the quality or extent of estuaries in the NCCC Domain.

1.4.6 Habitat Complexity

Habitat complexity is critically important for salmonids because complex habitats are typically highly productive, provide velocity refuges and places to hide from predators, and result in more suitable instream temperature regimes. To capture the diversity and importance of complex habitat features, five different indicators were used to evaluate this component: (1) LWD frequency; (2) shelter rating, (3) percent of primary and staging pools; (4) pool/riffle/flatwater ratio and (5) V*Star (pool volume).

1. LWD Bank Full Width (BFW) 0-10, or BFW 10-100
Steelhead Target: Adult, Summer and Winter Rearing, and Smolts
Chinook Target: Adults, and Pre Smolts and Smolts

Instream large wood has been linked to overall salmonid production in streams with positive correlations between LWD and salmonid abundance, distribution, and survival (Sharma and Hilborn 2001). Salmonids appear to have a strong preference for pools created by LWD (Bisson *et al.* 1982) and their populations are typically larger in streams with abundant wood (Naimen and Bilby 1998). Decreases in fish abundance occur following wood removal (Lestelle 1978; Bryant 1983; Bisson and Sedell 1984; Lestelle and Cederholm 1984; Dolloff 1986; Elliott 1986; Murphy *et al.* 1986; Hicks *et al.* 1991a) while increases in fish abundance have been found following deliberate additions of LWD (Ward and Slaney 1979; House and Boehne 1986; Crispin *et al.* 1993; Reeves *et al.* 1993; Naimen and Bilby 1998; Roni and Quinn 2001).

The LWD indicator is defined as the number of key pieces (frequency) of large wood per 100 meters of stream. The frequency of key pieces of LWD influences development and maintenance of pool habitat for multiple life stages of salmonids. Separate rating criteria were developed for channels with bankfull widths (BFW) less than 10 meters and greater than 10 meters. Key pieces are logs or rootwads that: (1) are independently stable within the bankfull width and not functionally held by another factor, and (2) can retain other pieces of organic debris (WFPB 1997). Key pieces also meet the following size criteria: (1) for bankfull channels 10 meters wide or less, a minimum diameter 0.55 meters and length of 10 meters, or a volume 2.5 cubic meter or greater, (2) for channels between 10 and 100 meters, a minimum diameter of 0.65 meters and length of 19 meters, or a volume six cubic meters or greater (Schuett-Hames *et al.* 1999). Key pieces in channels with a bankfull width of > 30 meters only qualify if they have a rootwad associated with them (Fox and Bolton 2007).

Methods:
Assessing watershed condition using these criteria proved problematic due to the absence of adequate LWD surveys in most areas in the NCCC Domain. For those watersheds without LWD survey data, SEC queried the percent LWD Dominant Pools attribute from the *Stream Summary Application* database. SEC also queried percent Pools with LWD and percent Shelter that is LWD from the Hab-8 data, but percent LWD Dominant Pools produced discernible breaks in the distribution of observed values that were consistent with expected results. We therefore used that Hab-8 attribute and assumed it provided a functional equivalent to LWD key piece frequency. Where Hab-8 data were lacking, the best available literature or knowledgeable individuals were consulted to inform best professional judgment ratings.

The Flosi *et al.* (2004) habitat typing survey methodology follows a random sampling protocol stratified by stream reach (*i.e.,* Rosgen Channel type) to assess stream habitat conditions from the mouth to the end of anadromy. Thus, habitat data can be utilized to characterize each reach of stream, and data can be averaged over the collection of reaches to characterize the stream. LWD is counted in the shelter value rating as one of the components of shelter in a pool and is estimated as a percentage of the total shelter available.

NMFS queried the *Stream Summary Application* (Appendix E) for LWD counts for each stream reach and then extrapolated the data to characterize each population stream, for all populations where the data existed.
The most challenging aspect of the LWD compilation was distilling data recorded in a variety of ways over a span of years into numbers that could be assigned to our rating system (Table 8). It is possible that some pieces of LWD recorded on some streams would not meet the criteria set for "key pieces" by this analysis. In some cases, the criteria were not included in the stream inventories; in others, size classifications did not correlate well with our divisions (1-2 foot diameter and more than 20 foot long vs. 0.55 m diameter and 10 m long, for example). Reach distances and bankfull widths were converted into meters. Sometimes LWD per 100 feet was provided for the habitat elements of riffles, pools, and flat water. In this case, it was necessary to find the percentage of each element given for a particular reach as well as the length for the whole reach and then back calculate the number of LWD in that reach.

Table 8. Examples of various data collection and recording methods illustrating potential sources of errors in LWD ratings.

LWD Recorded Terms	**Potential Error** and/or Comment	**Location(s)** (unless noted, includes sub basins)
"Debris Jams"	Underestimates # key pieces of LWD. Uncertainty was too high, so no rating was given.	Ten Mile River.
"Key LWD"	Criteria may not match	Noyo River Albion River
"Key pieces"	Criteria may not match	San Gregorio Creek
"LGWDDEB_NO" (Number of large woody debris)	Criteria may not match	Lagunitas Creek San Geronimo Creek
"LWD Forced Pool"	underestimates # of key pieces of LWD	Russian River sub basins: Willow Creek (Russian River) Freezeout Creek (Russian River) Unnamed tributaries (Russian River) Cottaneva Creek
"LWD per 100ft" for: "Riffles," "Pools," and "Flat."	(1)Where percent of each element was recorded, LWD per 100m was calculated.	Pudding Creek Big Salmon Creek Walker Creek

"Number of pieces per 100 linear feet of stream within the bankfull channel"	Criteria may not match. Live trees included in total were subtracted before calculating	Caspar Creek
"Pieces of large wood"	Criteria may not match	Soquel Creek Gazos Creek
"Total # LWD"	Different criteria for LWD than for key pieces of LWD	Pescadero Creek
"Total Logs w/Estimates from LDA's (# per mile)"	Criteria may not match	Aptos Creek
"Key LWD Pieces/328 ft. w/ Debris Jams"	Criteria may not match.	Navarro River Big River Russian River sub basins: Ackerman Creek Alder Creek Jack Smith Creek
"Total # of Debris Jams" + "Key LWD Pieces/100m w/o Debris Jams	Criteria may not match. Two totals were added (see comment for Navarro) Debris jams only recorded for 3 out of 22 reaches. In only one case did it change the rating—from Fair to Good.	Garcia River

Ratings:
Rating criteria were based on the observed distribution of key pieces of LWD in unmanaged forests in the Western Washington eco-region developed by Fox and Bolton (2007). Fox and Bolton's (2007) recommendations were followed using the top 75 percentile to represent a Very Good condition for LWD frequency. The California North Coast Regional Water Quality Control Board (NCRWQCB 2006) used similar information to develop indices for LWD associated with freshwater salmonid habitat conditions.

The resulting CAP and rapid assessment rating criteria are as follows:

For smaller channels (0-10 meters BFW):
Poor = < 4 key pieces/100 meters;
Fair = 4 to 6 key pieces/100 meters;
Good = 6 to 11 key pieces/100 meters; and
Very Good = > 11 key pieces/100 meters.

For larger channels (10-100 meters BFW):
Poor = < 1 key pieces/100 meters;

Fair = 1 to 1.3 key pieces/100 meters;
Good = 1.3 to 4 key pieces/100 meters; and
Very Good = > 4 key pieces/100 meters.

Stress:
The stress for this indicator was: Habitat Complexity: Large Wood & Shelter. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect Habitat Complexity.

2. <u>Shelter Rating</u>
Steelhead Target: Winter/Summer Adult, Summer and Winter Rearing, Smolt
Chinook Target: Pre-smolt, Smolt

Salmonids require pool habitats with adequate complexity and cover for all life stages. Shelter rating is a measure of the amount and diversity of cover elements in pools and is a useful indicator of pool complexity. Shelter rating is used by CDFW in their stream habitat-typing protocol (Flosi *et al.* 2004). Pool shelter rating was used to evaluate the ability of pool habitat to provide adequate cover for salmonid survival throughout the watershed. Shelter/cover elements include undercut banks, large and small woody debris, root masses, terrestrial vegetation, aquatic vegetation, bubble curtains, boulders, and bedrock ledges (Bleier *et al.* 2003). Winter habitat is lacking in situations where habitat lacking shelter elements dominate the channel. Such conditions lack refugia in the form of velocity refuge, cover and shelter for fish to maintain residency through storm periods.

Methods:
The Flosi *et al.* (2004) habitat typing survey method estimates shelter ratings in all pool habitats measured. Typically, pool habitats are described in every third habitat unit in addition to every fully-described unit which provides an approximate 30 percent sub-sample. Habitat data were used to characterize each reach of stream, and data were averaged over the collection of reaches to characterize the entire stream.

Shelter rating values were generated by multiplying instream shelter complexity values by estimating percent area of pool covered. Scores were obtained by assigning an integer value from 0 to 3 to characterize type and diversity of cover elements and multiplying that value by the percent cover (Table 9). A shelter rating from 0 to 300 is derived, with 300 being equal to 100% cover with maximum diversity (Flosi *et al.* 2004).

Table 9. Values and examples of instream shelter complexity. Values represent a relative measure of the quality and composition of the instream shelter. Adapted from Flosi et al., 2004.

Value	Instream Shelter Complexity
0	No Shelter
1	1-5 boulders
	Bare undercut bank or bedrock ledge
	Single piece of LWD (>12" diameter and 6' long)
2	1-2 pieces of LWD associated with any amount of small woody debris (SWD) (<12" diameter)
	6 or more boulders per 50 feet
	Stable undercut bank with root mass, and less than 12" undercut
	A single root wad lacking complexity
	Branches in or near the water
	Limited submersed vegetative fish cover
	Bubble curtain
3 (Combinations of at least 2 cover types)	LWD/boulders/root wads
	3 or more pieces of LWD combined with SWD
	3 or more boulders combined with LWD/SWD
	Bubble curtain combined with LWD or boulders
	Stable undercut bank with greater than 12" undercut, with root mass or LWD
	Extensive submerged vegetative fish cover

SEC calculated average shelter ratings across all reaches using Hab-8 reach summation information. This sub-sample is expressed as an average for each stream reach. SEC queried the stream summary database for mean percent shelter ratings for each stream reach and extrapolated the data to characterize each stream, within each population (where data were available). As with other reach level data, deriving ratings for each population required two steps: calculation of shelter value at the stream scale from reach scale data, then determining the percentage of streams/IP-km meeting optimal criteria at the population scale. A bias analysis was also conducted for the population shelter rating value reflecting the percent of potential IP km evaluated.

Ratings:
Bleier *et al*. (2003) identified a shelter rating value of < 60 as being inadequate, and > 80-100 as good for salmonids. Average shelter value below 80 was rated Fair; average shelter value above 100 was rated as Very Good. The stream level criteria are:

Stream level shelter rating
Poor = < 60 average shelter value;

Fair = 60 to 79 average shelter value;
Good = 80 to 100 average shelter value; and
Very Good = > 100 average shelter value.

Given that the population scale encompasses multiple streams, the following ratings were used to extrapolate shelter conditions for each population:

Population level shelter rating
Poor = < 50% of streams/IP-km rating Good or better;
Fair = 50% to 74% of streams/IP-km rating Good or better;
Good = 75% to 90% of streams/IP-km rating Good or better; and
Very Good = > 90% of streams/IP-km rating Good or better.

In situations where the "percent of streams" metric deviates from the "percent IP-km" metric and the rating criteria is not consistent (example: Poor versus Good), then the IP-km rating criteria is used as the default. Where Hab-8 data were lacking, a qualitative approach was utilized using the best available literature, spatial data and IP-km habitat potential to inform best professional judgment ratings.

Stress:
The stress for this indicator was: Habitat Complexity: Large Wood & Shelter. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect Habitat Complexity.

3. <u>Percent Primary and Staging Pools</u>
Steelhead Target: Adults, Summer Rearing (Primary Pools) and Summer Adults (Staging Pools)
Chinook Target: Adults, Pre Smolt, Smolt (Primary Pools) and Spawning Adults (Staging Pools)

Pools provide hydraulic and other environmental conditions favoring presence of summer rearing juvenile salmonids (Bisson *et al.* 1988). During high flow events, pools are usually scoured, leaving a coarse gravel channel armor and depositing material on the riffles (Florsheim *et al.* 2001). The percentage of pools within a stream is a common indicator for estimating amount of rearing habitat available for juvenile salmonids. The pool/riffle/flatwater indicator (below) describes the frequency of all pool habitat types (mid-channel, scour and backwater pools) relative to other habitat types across each population. However, quantitative information on pool frequency without accompanying qualitative information such as depth or shelter indicators and criteria, can give a false impression of health, if there are numerous, shallow, short simple pools (a common occurrence in aggraded streams). Primary and staging pools are the larger deeper pools utilized by juveniles and adults respectively, have specific depth criteria, and are a subset of all pool habitat types.

Deep large pools maximize the juvenile rearing carrying capacity. Additionally, larger deeper pools adjacent to riffle habitats are utilized by spawning adults for resting and cover between spawning events, and for staging summer steelhead on main-stem rivers during migration. The frequency of these larger deep pools provides a conservative measure of the quality of significant rearing and staging habitat. CDFW combined measures of pool depth and frequency in their North Coast Watershed Assessment Program (NCWAP) reports by reporting the frequency of primary pools stratified by stream order. Primary pools in first and second order streams[9] are defined as two feet deep or more, while primary pools in third and fourth order streams were defined as three feet deep or more (Bleier *et al.* 2003). Though no official criteria exists, we define staging pools in third and fourth order streams as >5 feet deep, and in larger stream orders (mainstem channels) >10 feet deep.

Juvenile salmonids prefer well shaded pools at least one meter deep with dense overhead cover or abundant submerged cover composed of undercut banks, logs, roots, and other woody debris. Deeper pools adjacent to riffle habitats provide staging areas for adult Chinook salmon during migration periods in the fall, and resting periods between spawning events. Pool depths of three feet are commonly used as a reference for fully functional salmonid habitat (Overton *et al.* 1993; Brown *et al.* 1994; Bauer and Ralph 1999; USFS 2000). Maximum pool depth is partially a function of watershed size, and is highly affected by the physical properties that affect stream energy such as gradient, entrenchment, width, and sediment. The Washington State Fish and Wildlife Commission (1997) (Knutson and Naef 1997) recommended the following pool frequencies by length: "(f)or streams less than 15 meters wide, the percent pools should be greater than 55%, greater than 40% and greater than 30%, for streams with gradients less than 2%, 2-5% and more than 5%, respectively."

Pool depths and volume can be compromised by sediment over-supply related to land management (Knopp 1993). Reeves *et al*. (1993) found that pools diminished in frequency in intensively managed watersheds. Streams in Oregon coastal basins with low timber harvest rates (<25%) had 10-47% more pools per 100 m than did streams in high harvest basins (>25%). Peterson *et al*. (1992) used 50% pools as a reference for good salmonid habitat and recognized streams with less than 38% pools by length as impaired (Murphy *et al.* 1984).

Methods:

[9] Stream order is a hierarchal measure of stream size. First order streams drain into second order streams, and so on. The presence of higher order streams suggests a larger, more complex watershed.

Habitat typing surveys (Flosi *et al*. 2004) provide a measure of pool frequency defined as the percentage of stream reaches in pools. SEC queried the *Stream Summary Application* (Appendix E) for the mean of each variable for each stream reach and then extrapolated the data to characterize each stream, for all streams within each population where data existed. In other populations other datasets and best professional judgment were utilized. Thus, to rate each population for this variable required two steps; calculation of the mean at the stream scale from reach scale data , then determining what percentage of streams/IP-km meet optimal criteria, at the population scale.

The frequency of staging pools in third and fourth order streams was calculated using the proportion of pools > 5 feet in depth. Larger stream orders (5+) and mainstem channels are not surveyed by CDFW using this methodology, so NMFS had to rely on other methods (best professional judgment, anecdotal information, summer steelhead surveys, *etc.*) to characterize pools > 10′ deep.

Ratings:
The CDFG Watershed Assessment Field Reference (Flosi *et al*. 2004) states good salmonid streams have more than 50% of their total available fish habitat in adequately deep and complex pools, though CDFW considers a primary pool frequency of less than 40% inadequate for salmonids (Bleier *et al.* 2003). Knopp (1993) summarized pool frequency in disturbed streams in Northern California, and found an average of 42%. Pool depth varies directly with stream order as a function of channel gradient, and entrenchment, and is also dependent upon substrate size. To extrapolate upward to the *stream scale*, we established rating criteria which used a quartile approach and an approximate 25% bound from a 50% threshold to describe good conditions for primary pools to account for bias due to stream order and the natural range of variability.

The resulting CAP and rapid assessment criteria for steelhead summer rearing target for primary pools are:

Stream level percent primary pool rating criteria
Poor = < 25% primary pools;
Fair = 25% to 49% primary pools;
Good = 50% to 74% primary pools; and
Very Good = ≥ 75% primary pools.

Population scale encompasses multiple streams (including mainstem channels which cannot always be expected to achieve optimal criteria across all stream orders). Therefore stream level data were evaluated according to the following criteria:

Population level percent primary pool rating criteria
Poor = < 50% of streams/IP-km rating good or better;
Fair = 50% to 74% of streams/IP-km rating good or better;

Good = 75-90% of streams/IP-km rating good or better; and
Very Good = > 90% of streams/IP-km rating good or better.

For staging pools, given that adults utilize these deeper pools at the same frequency as adjacent riffle habitats, we established rating criteria that used a 10% bound from the 20% threshold to describe good conditions to account for bias due to stream order and the natural range of variability.

The resulting criteria apply only to third and fourth order streams for summer adult steelhead and Chinook spawning adults are:

Stream level staging pool rating criteria
Poor = <10% staging pools
Fair = 11- 19% staging pools
Good = 20%-29% staging pools
Very Good = ≥30% staging pools

Given that the *population scale* encompasses multiple streams and in some cases, multiple watersheds (including mainstem channels which cannot be expected to achieve optimal criteria across all stream orders), to extrapolate stream level data upward to the *population scale*, we rated each population on the following criteria:

Population level rating criteria
Poor = < 50% of streams/IP-km rating Very Good or better
Fair = 50% to 74% of streams/IP-km rating Very Good or better
Good = 75-90% of streams/IP-km rating Very Good or better
Very Good = > 90% of streams/IP-km rating Very Good or better

In situations where the "% of streams" metric deviates from the "% IP-km" metric the rating criteria is not consistent (*e.g*. Poor vs. Good), then the IP-km rating criteria are used as the default. Where Hab-8 data was lacking, a qualitative approach was utilized using the best available literature, spatial data and IP-km habitat potential to inform best professional judgment ratings.

Stress:
The stress associated with this indicator Habitat Complexity: Percent Primary Pools & Pool/Riffle/Flatwater Ratios. For Chinook salmon, the stress was indicator Habitat Complexity: Percent Primary/Staging Pools & Pool/Riffle/Flatwater Ratios. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect Habitat Complexity.

4. <u>Pool/ Riffle/ Flatwater Ratio</u>
Steelhead Target: Adult, Summer Rearing, Winter Rearing

Chinook Target: Adults, Pre Smolt, Smolts

Pools provide hydraulic and other environmental conditions necessary for summer rearing of juvenile salmonids and resting cover for adults. Riffles provide hydraulic and environmental conditions critical for spawning adults and incubating eggs. Adjoining flatwater provides habitat for all life stages. In general, winter habitat is lacking where flatwater habitats dominate the channel, because they lack elements (velocity refuge, scour elements, cover and shelter) for fish to maintain residency under high flow conditions. The average frequency of pools/riffles/flatwater across all IP-km provides an indication of the habitat diversity available for various species and life stages.

Developing or enhancing pool habitats for rearing and riffle habitats for spawning are a common focus of restoration activities. When pools lack depth or shelter, actions are typically recommended to deepen pools by adding instream complexity. This ultimately shortens adjoining flatwater types, or converts flatwater habitat types to pools. Conversely, when spawning gravels are lacking, actions are typically recommended to add instream structures as a technique to flatten the gradient and retain gravels. This ultimately shortens adjoining flatwaters or converts flatwater habitat types to riffles. In this case, the length or frequency of flatwater types is decreased in favor of increasing the length or frequency of pools/riffles.

Methods:
CDFW habitat typing identifies the attributes distinguishing various habitat types including stream order, over-all channel gradient, velocity, depth, substrate, and the channel type features responsible for the unit's formation. However, habitat can be summarized at any habitat scale and used to characterize each reach of stream, as well as the stream as a whole. The length and frequencies of a habitat type depend on stream size and order. Generally a stream will not contain all habitat types, as the mix of habitat types reflects the overall channel gradient, flow regime, cross-sectional profile, and substrate particle size. Categorizing riffles into riffle or flatwater habitat types, for a total of three types (riffle, pool, and flatwater) provides a reasonable measure of diversity to describe the complexity of habitats that occur across watersheds, which also describes the critical habitat needs across species in a population. SEC calculated the frequency of pools, riffles and flatwater from the *Stream Summary Application* (Appendix E) for pool/riffle/flatwater frequency for each stream reach and extrapolated the data to characterize each stream, for all streams within each population where the data existed. As with other data collected at smaller scales, rating each population required two steps; calculation of the mean at the stream scale from reach scale data and then determining the percentage of streams/IP-km meeting optimal criteria, at the population scale.

Ratings:
As noted above, Reeves *et al*. (1993) found pools diminished in frequency in intensively managed watersheds. Streams in Oregon coastal basins with low timber harvest rates (<

25 percent) had 10-47 percent more pools per 100 m than did streams in high harvest basins (> 25 percent). The CDFG Watershed Assessment Field Reference (CDFG 1999) states good salmonid streams have more than 50 percent of their total available fish habitat in adequately deep and complex pools; and have at least 30 percent in riffles. Knopp (1993) summarized pool frequency in disturbed streams in Northern California, and found pool frequency averaged 42 percent.

CDFW considers a primary pool frequency of less than 20 percent, and riffle frequency less than 10 percent inadequate for salmonids (Bleier *et al.* 2003). Based on this consideration, NMFS established rating criteria using a 10 percent boundary from the target threshold for subsequent ratings for pools and riffles, with the remainder assumed to be flatwater. The resulting rating criteria are:

Stream level pool/riffle/flatwater frequency rating
Poor = < 20% pools and < 10% riffles;
Fair = 20% to 29% pools and 10% to 19% riffles;
Good = 30% to 39% pools and = 20% to 29% riffles; and
Very Good = ≥ 40% pools and = ≥ 30% riffles.

To extrapolate stream level data upward to the population scale, we then rated each population on the following criteria.

Population level pool/riffle/flatwater frequency rating
Poor = < 50% of streams/IP-km rating Good or better;
Fair = 50% to 74% of streams/IP-km rating Good or better;
Good = 75% to 90% of streams/IP-km rating Good or better; and
Very Good = > 90% of streams/IP-km rating Good or better.

Stress:
The stress associated with this indicator was Habitat Complexity: Percent Primary Pools & Pool/Riffle/Flatwater Ratios. For Chinook salmon, the stress was indicator Habitat Complexity: Percent Primary/Staging Pools & Pool/Riffle/Flatwater Ratios. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect the Habitat Complexity.

5. <u>Indicator: V*Star</u>
NC Steelhead Target: Winter Adults, Winter/Summer Rearing
Chinook Target: Spawning Adults, Pre smolt

Pool volume is a good surrogate for juvenile rearing space and stream carrying capacity because of the species' recognized preference for pools (Reeves *et al.* 1989). Hilton and Lisle (1993) devised a method to quickly assess the ratio of the volume of sediment and water in a pool to the volume of sediment alone, to determine the residual volume of pools, and termed the measure V-star or V*.

Methods:
Knopp (1993) found a high correlation in northwestern California between the intensity of land use and residual pool volume as reflected by V*, with highly disturbed watersheds having values greater than 0.21. Regional TMDLs (1998) and the NCRWQCB (2006) both use a V* score of 0.21 as a target for fully functional conditions. NMFS CAP V* reference values reflect the findings of Knopp (1993) and the TMDL and NCRWQCB recommendations.

Ratings:
Data for V* were not available for most populations assessed in the Multi-species Recovery Plan. The V* attribute was used consistently in the SONCC Recovery Plan, and therefore V* data were used to evaluate conditions only in populations which overlapped with the SONCC Recovery Plan. Mean values were used to rate at the population scale. Ratings for these populations were adopted based on Knopp (1993) and available TMDLs as follows:

Population level rating criteria
Poor = >0.35
Fair = 0.22-0.35
Good = 0.15 - 0.21
Very Good = <0.15

Stress:
The stress associated with this indicator was Habitat Complexity: Percent Primary Pools & Pool/Riffle/Flatwater Ratios. For Chinook salmon, the stress was indicator Habitat Complexity: Percent Primary/Staging Pools & Pool/Riffle/Flatwater Ratios. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect the Habitat Complexity.

1.4.7 HYDROLOGY

Hydrology, as a key attribute, includes all aspects of the hydrologic cycle relevant to the spawning, incubation, rearing and migration of salmonids. The magnitude, timing, and seasonality of local precipitation and geology determine a watershed's historical discharge patterns. These patterns however, can be modified by individual and cumulative water use practices to interfere with a salmonid's ability to complete its life cycle. Since these species evolved under unimpaired flow regimes, it is reasonable to assume that approximating those conditions will likely foster favorable conditions.

Methods:
Hydrology was assessed using five different indicators: (1) redd scouring events; (2) flow conditions (baseflow and instantaneous conditions), (3) passage flows; (4) the number, condition and/or magnitude of diversions, and (5) impervious surfaces. All flow-related indicators were assessed using the instream flow protocol conducted by a team of experts and NMFS analysts. The number, condition and/or magnitude of diversions were assessed using several data sets. Impervious surfaces were evaluated using GIS land use data. For most watersheds, there is generally little information about the suitability of flows to support these indicators, although there may be sufficient data for some individual sub-watersheds, and for others there may be data for only one or two of the five attributes.

To develop ratings for the final CCC coho salmon recovery plan (NMFS 2012), NMFS assessed instream flow conditions using the instream flow protocol with input from 15 fisheries researchers and aquatic resource managers familiar with stream flow issues in north-central coastal California. The hydrologic conditions (*i.e*., the quantity of flow) necessary to support coho salmon are very similar for steelhead and CC Chinook. Summer rearing baseflow needs are similar for the species; incubating eggs and fry of all three species are similarly vulnerable to redd scour and instantaneous flow reductions, and the flows needed by downstream migrating smolts of these species are similar. The only substantive difference in the flows needed by coho salmon, steelhead, and CC Chinook are the timing of flows needed for adult upstream migration. Upstream migrations of adult coho salmon typically begin in mid-October to mid-November and peak in December or early January. Adult migrations of steelhead and CC Chinook generally begin in late November or early December and peak in February or March. For these reasons we applied the results of the instream flow assessment developed for the CCC coho salmon recovery plan to rate the instream flow attributes for steelhead and CC Chinook, with the exception that NMFS analysts reviewed the ratings for adult upstream passage flows for coho and modified them for adult steelhead and CC Chinook migration, where information warranted it.

To evaluate instream flow habitat attributes for watersheds not assessed in the CCC coho salmon recovery plan (those from Redwood to Wages creeks; watersheds supporting historic functionally and potentially independent populations in the Russian River; and those supporting steelhead in Interior and Coastal San Francisco Bay Diversity Strata for CCC steelhead) we adopted a methodology similar to that employed for CCC coho salmon. Rather than solicit input from a large number of resource managers familiar with instream flow conditions in north-central coastal California, NMFS analysts reviewed existing information for these streams and developed ratings for each of the five habitat attributes as defined below.

Spatial and Temporal Definitions:

The distribution and differences in seasonality of each life stage must be considered so as to better assess the nature of flow-related impacts on them.

We defined distribution as the likely historical extent of the species at each life stage in a watershed, as opposed to the current distribution. The historic distribution was adopted based on the TRT historical population structure report and their assumption that historical habitat represents the best case scenario for species recovery. The extent and distribution of historic habitat (IP-km) has been defined by the TRT. The analysts conducting the assessment were provided with maps showing the distribution of IP stream reaches for all essential or supporting watersheds.

The seasonality of each life stage is another important consideration because seasonality can co-occur with seasonally-specific water demands. For example, flow reductions associated with diversions for frost protection are more likely to occur in the early spring, which is in turn more likely to affect incubating embryos than it would summer rearing juveniles. For the purposes of this assessment, we defined the period of each life stage according to the dates in Table 10.

Table 10. Critical period for each life stage for evaluation of flow attributes.

Life Stage	Begin Date	End Date
Egg (Incubation)	1-Dec	15-May
Summer Rearing	1-Jul	1-Oct
Smolt (Migration)	1-Mar	1-Jun
Adult (Migration)	1-Dec	15-April

Scoring Method:

The potential of each watershed to support any habitat attribute varies and is dependent not only on land use but on watershed size, local precipitation, and other climatic and geologic features. The analyst rating the flow conditions of a watershed reviewed relevant published information and input from resource managers and researchers familiar with the state of instream flows within a given watershed. The NMFS analyst then scored each of the five flow related habitat attributes for three risk factors: *setting, exposure and intensity*, as defined below.

Setting rates the degree of aridity of a watershed given the natural setting of climate, precipitation, etc. in an undisturbed state. We identified four classes of setting: xeric, mixed, mesic, and coastal. *Xeric* watersheds are those dominated by arid environments such as oak savannah, grassland, or chaparral. *Mixed* watersheds are those that have a mix of xeric, mesic, and/or coastal habitats within them; as with large watersheds with inland regions. *Mesic* settings are those environments with moderate amounts of precipitation; examples include mixed coniferous/hardwood forest and hardwood-dominated forest (*e.g.*, oak woodland, tanoak, etc.). *Coastal* refers to watersheds dominated by the coastal climate regime with cool moist areas. These watersheds typically have high levels of precipitation, are heavily forested, and are predominantly within the redwood zone. Maps of each watershed will be provided to show vegetation types and average precipitation for review. The analyst rated the watershed setting using this information and their general knowledge of the watershed.

Exposure rates the extent of stream likely impaired relative to each flow attribute. Specifically, exposure is the estimated proportion of historical IP-km habitat (by length) appreciably affected by reduced flows. A stream reach may be appreciably affected, for example, if the value of summer rearing habitat is degraded by water diversions that reduce space, degrade water quality, reduce food availability, or restrict movement. The NMFS biologist was provided with maps of each watershed showing the spatial relationship between relevant habitat areas and high-risk land uses, such as agriculture. The biologist then rated the exposure (% IP-km habitat by length) as >15%, 5-15%, <5%, or none based on existing information and their knowledge of local land uses.

Intensity rates the likelihood that the land uses within the area of exposure will divert substantial amounts of water during the time in question. We define High Intensity land use activities as those that regularly require substantial water diversions from the stream at levels that impair flows. We define Moderate intensity activities as those that typically require irrigation, or have regular demand, but satisfy that demand often by means other than direct pumping of surface or subterranean stream flows. We define Low land use activities as those that only require diversions in small amounts. NMFS analysts rated the intensity of the water diversion impacts in the watershed as high, moderate, low, or none using existing information and their knowledge of local land uses.

NMFS analysts derived overall scores for each of the five flow-related habitat attributes on each applicable life stage in two steps. For a given habitat attribute, each risk-factor rating is first assigned a value as defined in Table 11. Then, the three risk factor rating scores were averaged to determine the overall rating. For example, to determine the rating for Baseflow on Summer Rearing in the Napa River, the Setting is Mixed (score of 75), the Exposure (of historic potential rearing habitat) to impacts of impaired summer base flows was >15% (score of 100), and the Intensity was High (score of 100), the average score of these three risk factors is 92, which results in an attribute rating of "Major Effect" for summer rearing base flows.

Table 11. Risk-factor scores and the classes defining Major Effect, Moderate Effect, Minor Effect, and Negligible Effect ratings for combined average risk score for each life stage and each indicator.

	Major Effect	Moderate Effect	Minor Effect	Negligible Effect

Setting	Xeric	Mixed	Mesic	Coastal
Score	100	75	50	25
Exposure	>15%	5-15%	<5%	None
Score	100	75	50	25
Intensity	High	Moderate	Low	None
Score	100	75	50	25
Attribute Rating Score	>75	51-75	35-50	<35

Minimum Data Requirements:
Recognizing that, for some watersheds, data may be very limited or non-existent for Exposure and Intensity ratings for individual flow-related habitat attributes, it is important that analysts provided reliable sources for these ratings. Ratings were not solely based on professional judgment and/or personal communications. Wherever possible, at least one quality reference (published document, agency report, *etc*.) was cited for each habitat attribute rating, and these references were supplemented with "personal communications" with local experts if possible. In cases where flow conditions (Exposure and/or Intensity) related to a particular habitat attribute could not be determined, the attribute was scored "unknown". Such ratings result in recovery action recommendations for further investigation of the suitability of flow conditions for that attribute.

1. <u>Redd Scouring Events</u>
Steelhead Target: Eggs
Chinook Target: Eggs

Redd scour refers to the mobilization of streambed gravels at spawning sites that result in the dislodging of salmonid embryos developing in subsurface gravels and subsequent mortality. While this process is not strictly a function of stream flows, storm flow events combined with channel configuration, sediment dynamics, and channel roughness and stability largely control the stability of spawning substrates.

Methods:
The ratings for each population for this indicator were determined based on the results of the instream flow protocol, NMFS' analysis of watershed reports, co-manager documentation and knowledge, literature reviews, and best professional judgment.

Ratings:
We defined rating criteria for this indicator in the following manner:

Poor = Risk Factor Score >75
Fair = Risk Factor Score 51-75

Good = Risk Factor Score 35-50
Very Good = Risk Factor Score <35

Stress:
The stress for this attribute was Hydrology: Redd Scour and it was compared against all threats except Disease/Predation/Competition, Fishing/Collecting and Hatcheries, which do not affect gravel scouring events.

2. <u>Flow Conditions (Baseflow, and Instaneous Conditions)</u>
Steelhead Target: Adults, Eggs, Summer Rearing, Summer Adults
Chinook Target: Eggs, Pre-Smolt, Smolts

Baseflow is an indication of the degree to which a watershed currently supports surface flows within historical rearing areas. Surface flows provide rearing space, allow for movement between habitats, maintain water quality, and facilitate delivery of food for juvenile salmonids. Inadequate surface flow may be the result of cumulative water diversions and/or significant physical changes in the watershed.

Instantaneous flow reductions provide an indication of the degree to which short-term artificial streamflow reductions impact juveniles or the survival to emergence of incubating steelhead or CC Chinook embryos embedded in their redds. This condition is often associated with instream diversions (*e.g.*, frost protection irrigation) and can be exacerbated in more arid conditions.

Methods:
The ratings for each population for this indicator were determined based on the results of the instream flow protocol, NMFS' analysis of watershed reports, co-manager documentation and knowledge, literature reviews, and best professional judgment.

Ratings:
We defined rating criteria for this indicator in the following manner:

Poor = Risk Factor Score >75
Fair = Risk Factor Score 51-75
Good = Risk Factor Score 35-50
Very Good = Risk Factor Score <35

Stress:
The stress for this attribute was Hydrology: Baseflow & Passage Flows, and it was compared against the threats Channel Modification, Severe Weather, and Water Diversions and Impoundments, which can directly affect flows.

3. <u>Passage Flows</u>
Steelhead Target: Adults, Smolts, Summer Adults
Chinook Target: Adults, Pre-Smolt, Smolts

Passage into and out of tributaries from the mainstem migratory reaches or estuaries is critical for spawning adults and emigrating smolts. Juvenile salmonids also have been shown to migrate during the summer rearing phase.

Seasonal patterns in rainfall combined with land use activities which may affect channel aggradation or degradation may limit the ability of fish to migrate into and out of tributaries, or into or out of mainstem channels, completely or partially. Depending upon rainfall year, low flows may leave tributaries disconnected from their mouth due to severe aggradation, or as 'perched' channels due to incision. Tributaries that are inaccessible during the adult migration period may preclude the adult spawning population utilizing historic habitats, during a portion of the run, or in some or all years, depending upon localized channel conditions. Spawners waiting for flows to rise are likely more susceptible to predation and other forms of mortality such as recreational fishing. The longer the delay in adequate flows the more compressed the migration window and likely, the smaller the run or recruitment from the spawning population. Smolts must also leave smaller tributaries to access the mainstem on their downstream migration to the sea at a particular period in time. Summer rearing juveniles migrate frequently as streams dry up to utilize wetter or cooler habitats, or for natural dispersal patterns.

Methods:
Using the instream flow protocol, this indicator considered the effect of flow impairments on smolt and adult passage. Considerations included: (1) impairment precluding passage over critical riffles, and (2) the degree flow impairments reduce pulse-flows that facilitate successful immigration and emigration, including considerations of the magnitude, duration, and timing of freshets that facilitate efficient transport of fish. Additional conditions which were considered included: (1) annual variability in passage, (2) seasonality of passage conditions, (3) severity of condition, and (4) geographic scope of flow impairment.

Ratings:
Ratings for this indicator follow those for other passage/migration indicators. Passage was evaluated according to the time period specific to each life stage.

We defined rating criteria for this indicator in the following manner:

Poor = <50% or <16 IP-km of historical IP-km accessible
Fair = 50% to 74% of historical IP-km habitat accessible
Good = 75% to 90% of historical IP-km accessible
Very Good = >90% of historical IP-km accessible

Ratings for Poor conditions addressed accessible proportions of the watershed, and the minimum threshold of potential habitat (expressed as IP-km) required for the population to be considered viable -in-isolation (20 IP-km for Chinook salmon, and 16 IP-km for steelhead). These thresholds assume populations historically operated close to the natural carrying capacity of the watershed.

Stress:
The stress for this attribute was Hydrology: Baseflow & Passage Flows, and it was compared against the threats Channel Modification, Severe Weather, and Water Diversions and Impoundments, which can directly affect flows.

4. Number, Condition, and/or Magnitude of Diversions
Steelhead Target: Summer Rearing, Smolt
Chinook Target: Pre-smolt, Smolt

Diversions are withdrawals from stream surface waters and/or from subterranean stream flows that are likely to be hydrologically connected to the stream (*e.g.,* pumping from wells in alluvial aquifers that are in close proximity to the stream). Diversions have the potential to not only reduce flows, but also cause entrainment or impingement of several juvenile life stages. We defined the indicator as the frequency of diversions along the IP-km smolt outmigration route. The diversion structures or sites included in our analysis were defined as diversions located along the stream channel. Those diversions that do not have an actual structure in the stream were not included in our analysis. Due to data limitations this rating only looked at the number of diversions and was not able to identify whether existing diversions are screened according to guidelines for fish passage.

Methods:
SEC initially queried the Pacific States Marine Fisheries Council Passage Assessment Database (PSMFC 2006) to identify diversions, their distribution across all IP-km, and volume of diversion authorized. SEC also targeted the California State Water Resources Control Board (SWRCB) Division of Water Rights Point of Diversion (POD) database. However, SEC was unable to determine the volume of water associated with each diversion. We therefore based the diversion indicator on the density of diversions regardless of volume. The diversion density was calculated as the number of diversions per 10 km of IP-km.

Ratings:
SEC assessed the density of diversions in each watershed across all IP-km, regardless if those areas are currently accessible by salmonids. As with the other attributes and indicators, this allowed us to assess conditions throughout all areas of potential importance to recovery, not just within the species' current distribution.

We established rating criteria based on the density of diversions in each population, NMFS' analysis of watershed reports, co-manager documentation and knowledge, literature reviews, and best professional judgment.

Poor = > 5 Diversions / 10 IP-km
Fair = 1.1 – 5 Diversions / 10 IP-km

Good = 0.01 – 1 Diversions / 10 IP-km
Very Good = 0 Diversions / 10 IP-km

Stress:
The stress for this attribute was Hydrology: Baseflow & Passage Flows, and it was compared against the threats Channel Modification, Severe Weather, and Water Diversions and Impoundments, which can directly affect flows.

5. <u>Impervious Surfaces</u>
Steelhead Target: Watershed Processes
Chinook Target: Watershed Processes

Modifications of the land surface (usually from urbanization) produce changes in both magnitude and type of runoff processes (Booth *et al.* 2002). Manifestation of these changes include increased frequency of flooding and peak flow volumes, decreased base flow, increased sediment loadings, changes in stream morphology, increased organic and inorganic loadings, increased stream temperature, and loss of aquatic/riparian habitat (May *et al.* 1996). The magnitude of peak flow and pollution increases with total impervious area (TIA) (*e.g.*, rooftops, streets, parking lots, sidewalks, *etc*.).

Spence *et al*. (1996) recognized channel damage from urbanization is clearly recognizable when TIA exceeds 10 percent. Reduced fish abundance, fish habitat quality and macroinvertebrate diversity was observed with TIA levels from 7.01-12 percent (Klein 1979; Shaver *et al.* 1995). May *et al*. (1996) showed almost a complete simplification of stream channels as TIA approached 30 percent and measured substantially increased levels of toxic storm water runoff in watersheds with greater than 40 percent TIA.

Methods:
The primary assessment tool used was the National Land Cover Database (Edition 1.0) which was produced by the Multi-Resolution Land Characteristics Consortium. Statistics for percent coverage of each land cover type with an associated imperviousness rating were calculated using GIS thresholds for TIA from Booth (2000), May *et al*. (1996) and Spence *et al.* (1996).

Ratings: Percentage of impervious surfaces in a watershed was defined as:

Poor = > 10% of the total watershed;
Fair = 7% to 10% of the total watershed;
Good = 3% to 6% of the total watershed; and
Very Good = < 3% of the total watershed.

Stress:
The stress for this attribute was Hydrology: Baseflow & Passage Flows, and it was compared against the threats Channel Modification, Severe Weather, and Water Diversions and Impoundments, which can directly affect flows.

1.4.8 Landscape Patterns: Landscape Disturbance

Steelhead Target: Watershed Processes
Chinook Target: Watershed Processes

We defined landscape patterns as disturbance resulting from land uses that cause perturbations resulting in direct or indirect effects to watershed processes. These are typically the result of large scale land uses such as agriculture, timber harvest, and urbanization. These land uses were used as indicators to describe the degree of disturbance in a population.

1. Agriculture

Agriculture is defined as the planting, growing, and harvesting of annual and perennial non-timber crops for food, fuel, or fiber. Irrigated agriculture can negatively impact salmonid habitat (Nehlsen *et al.* 1991) due to insufficient riparian buffers, high rates of sedimentation, water diversions, and chemical application and pest control practices (Spence *et al.* 1996). Agricultural activities near streams are typically assumed to have more negative effects on streams than agriculture further away from streams due to the potential for stream channelization, clearing of riparian vegetation, and increased erosion, even though it may be planted on level ground. However, vineyards or other agriculture planted on steep terrain may contribute to instream sedimentation even when located a substantial distance from stream channels.

Specific methods for conserving salmonid habitats on agricultural lands are not well developed but the principles for protecting streams on agricultural lands are similar to those for forest and grazing practices (Spence *et al.* 1996).

Methods:
Assessments of agriculture were conducted via GIS interpretation of digital data layers. The California Department of Conservation, Division of Land Resource Protection, Farmland Mapping and Monitoring Program (FMMP) was the primary method used to measure the extent of agriculture in a population. Where these data were not available, USGS National Land Cover Database Zone 06 Land Cover Layer (Edition 1.0) was used. The FMMP data are presented by county, therefore where a population extended into more than one county the layers were merged to create a single dataset. The area represented by farmland polygons for each population was calculated using GIS.

Ratings
We defined ratings based on the observed distribution of results. The following rating criteria were thus formed:

> Poor = >30% of population area used for agricultural activities;
> Fair = 20% to 30% of population area used for agricultural activities;
> Good = 10% to 19% of population area used for agricultural activities; and
> Very Good = < 10% of population area used for agricultural activities.

Stress:
The stress associated with this indicator was Landscape Patterns: Agriculture, Timber Harvest & Urbanization. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect Landscape Patterns.

2. <u>Timber Harvest</u>
Adverse changes to salmonid habitat resulting from timber harvest are well documented in the scientific literature (Hall and Lantz 1969; Burns 1972; Holtby 1988; Hartman and Scrivener 1990; Chamberlin *et al.* 1991; Hicks *et al.* 1991a). The cumulative effects of these practices include changes to hydrology (including water temperature, water quality, water balance, soil structure, rates of erosion and sedimentation, channel forms and geomorphic processes (Chamberlin *et al.* 1991) which adversely affect salmonid habitats. These processes operate over varying time scales, ranging from a few hours for coastal streamflow response, to decades or centuries for geomorphic channel change and hill-slope evolution (Chamberlin *et al.* 1991).

Reeves *et al.* (1993) found that pools diminished in frequency in intensively managed watersheds. Streams in Oregon coastal basins with low timber harvest rates (< 25 percent) had 10 to 47 percent more pools per 100 meters than did streams in high harvest basins. Additionally, Reeves *et al.* (1993) correlated reduced salmonid assemblage diversity to rate of timber harvest. Rate of timber harvest was used to define the percent of a population exposed to timber harvest activities within the most recent 10 year period. As noted above, the 10 year time period is part of the standard CAP methodology and protocol.

Methods:
Cal Fire's timber harvest history information was used to determine the aerial extent of approved timber harvest plans, by population. However, we only included the aerial footprint once in this analysis regardless of the number of times an area was harvested in the 10 year period.

The 25 categories of timber harvest in California were initially condensed in the following general categories: even aged harvest, uneven aged harvest, conversion, no harvest, and transition. However, due to the relatively short ten year period, it was determined the only areas excluded from the rate-of-harvest analysis would be those where "no harvest" was included in the timber harvest plan. We acknowledge the different effects of the various silvicultural techniques (*i.e.*, even aged versus uneven aged harvest) but decided to combine all these harvest methods in order to capture all the potential cumulative effects of timber harvest within a population.

Ratings: Average rate of timber harvesting in population over last 10 years
Studies have identified a range of forest harvest rate thresholds (percent of watershed area over time) as indicators for concern. Ligon *et al*. (1999) recommend a harvest limitation of 30-50 percent of the watershed area harvested per decade as a "red flag" for a higher level of review. Recent work in the Mattole River suggests a harvest threshold of 10 to 20 percent of the watershed area (Hartwell Welsh, Redwood Sciences Laboratory, personal communication, 2010). Meanwhile, Reid (1999) concluded harvest rate of 15 percent of a watershed area is considered excessive for some timberlands. The range of thresholds is attributed to watershed-specific differences including slope, soils, climate, and tree density. Based on these findings we defined the following rating criteria for timber harvesting rate per population:

> Poor = >35% of population area harvested in the past 10 years;
> Fair = 26% to 35% of population area harvested in the past 10 years;
> Good = 15% to 25% of population area harvested in the past 10 years; and
> Very Good = <15% of population area harvested in the past 10 years.

Stress:
The stress associated with this indicator was Landscape Patterns: Agriculture, Timber Harvest & Urbanization. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect Landscape Patterns.

3. <u>Urbanization</u>
Urbanization was defined as the growth and expansion of the human landscape (characterized by cities, towns, suburbs, and outlying areas which are typically commercial, residential, and industrial) such that the land is no longer in a relatively natural state. The consequences of urbanization to aquatic ecosystems are severe and long-lasting. The land surface, soil, vegetation, and hydrology are all significantly altered in urban areas. Major changes associated with increased urban land area include increases in the amounts and variety of pollutants in runoff, more erratic hydrology due to increased impervious surface area and runoff conveyance, increased water temperatures due to loss of riparian vegetation and warming of surface runoff on exposed surfaces, and reduction in channel and habitat structure due to sediment inputs, bank destabilization, channelization, and restricted interactions between the river and its land margin (Paul and Meyer 2001; Allan 2004). Enhanced runoff from impervious surfaces and stormwater conveyance systems can degrade streams and displace organisms simply because of greater frequency and intensity of floods, erosion

of streambeds, and displacement of sediments (Lenat and Crawford 1994). Urban runoff which contains a variety of pollutants that degrade water quality (Wang *et al.* 2001), and reductions in overall biological diversity and integrity have been shown to be negatively correlated with the percentage of urban land cover (Klein 1979; Steedman 1988; Limburg and Schmidt 1990; Lenat and Crawford 1994; Weaver and Garman 1994; Wang *et al.* 1997; Klauda *et al.* 1998). Yates and Bailey (2010) reported declining numbers of benthic macroinvertebrate taxa, and replacement of intolerant taxa with more tolerant (often warm water) taxa, due to increasing density of human development. Wang *et al.* (1997; 2000; 2001) found that relatively low levels of population urbanization inevitably lead to serious degradation of the fish community.

While agricultural and timber land uses have best management land use practices that, if properly implemented, can minimize adverse impacts to watershed process, the impacts of urbanization are generally permanent. Additionally, while conservation measures exist for reversing or mitigating the degree of impervious surfaces (*e.g*. expanding riparian corridors, developing settling basins, storm water treatment, *etc.*), the other effects of urbanization can permanently alter natural watershed processes, and in some cases, little may be done to mitigate these effects.

Anadromous fish have been shown to be adversely affected by urbanization. Wang *et al*. (2001) found the impacts of urbanization occur to stream habitat and fish across multiple spatial scales, and that relatively small amounts of urban land use in a watershed can lead to major changes in biota. There also appears to be threshold values of urbanization beyond which degradation of biotic communities is rapid and dramatic (May *et al.* 1997; Wang *et al.* 2000).

Limburg and Schmidt (1990) demonstrated a measurable decrease in spawning success of anadromous species (primarily alewives) for Hudson River tributaries from streams with 15 percent or more of the watershed area in urban land use. Stream condition almost invariably responds nonlinearly to a gradient of increasing urban land or impervious area (IA). A marked decline in species diversity and in the index of biological integrity scores with increasing urbanization has been reported from streams in Wisconsin around 8–12 percent IA (Wang *et al.* 2000; Stepenuck *et al.* 2002), Delaware, 8–15 percent IA, (Paul and Meyer 2001), Maryland, greater than 12 percent IA, (Klein 1979), and Georgia, 15 percent urban land (Roy *et al.* 2003). Additional studies reviewed in Paul and Meyer (2001) and Stepenuck et al. (2002) provide evidence of marked changes in discharge, bank and channel erosion, and biotic condition at greater than 10 percent imperviousness. Also, the supply of contaminants in urban storm runoff may vary independent of impervious area (Allan (2004). Although considerable evidence supports a threshold in stream health in the range of 10 to 20 percent IA or urban land, others disagree (Karr and Chu 2000; Bledsoe and Watson 2001), and the relationship is likely too complex for a single threshold to apply.

Methods:
The primary method used to measure the extent of urban development in a watershed (population) was to query data from the California Department of Forestry and Fire Protection, Fire and Resource Assessment Program (FRAP), and from the GIS layer of DENCLASS10. This GIS layer provided year 2000 census block data, merged with county Topologically Integrated Geographic Encoding and Referencing (TIGER) files, into a single statewide data layer. These data sources provided a detailed depiction of spatial demographics. The data were used to summarize and describe the percentage of urban development for each population.

Ratings:
The rating criteria were defined as:

Poor = > 20% of watershed area in urban > 1 unit/20 acres;
Fair = 12% to 20% of watershed area in urban > 1 unit/20 acres;
Good = 8% to 11% of watershed area in urban > 1 unit/20 acres; and
Very Good = < 8% of watershed area in urban > 1 unit/20 acres.

Stress:
The stress associated with this indicator was Landscape Patterns: Agriculture, Timber Harvest & Urbanization. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect Landscape Patterns.

1.4.9 PASSAGE/MIGRATION

Steelhead Target: Adults, Summer Rearing, Smolts, Summer Adults
Chinook Target: Adults, Pre-Smolt, Smolts

Passage was assessed using two different metrics. Under the attribute Hydrology: Passage Flows (Section 1.4.7 above) flow conditions that support passage were assessed as a percentage of the accessible IP-km. This attribute, Passage/Migration, was assessed separately using two indicators: (1) passage at the mouth or confluence, and (2) physical barriers.

Passage was defined as the absence of physical barriers that prevent or impede the up- or downstream passage of migrating adults, smolts, and juvenile salmonids. Excluding spawning salmonids from portions of their IP-km can increase the likelihood of extirpation by reducing the amount of available spawning and rearing habitat and thereby lower the carrying capacity of the watershed (Boughton *et al.* 2005). Assessment of the percentage of IP affected by barriers should include all IP-km (including upstream of impassable dams if they are proposed for remediation). Passage requirements were evaluated individually for each target, according to the time period specific to each life stage.

1. <u>Passage at Mouth or Confluence</u>

Passage into and out of tributaries from the mainstem migratory reaches or estuaries is critical for spawning adults and emigrating smolts. Juvenile salmonids also move between stream reaches during the summer rearing phase.

Channel conditions may limit salmonid migration into and out of tributaries and mainstem channels. Tributaries inaccessible due to aggradation or channel incision may preclude the adult spawning population from accessing historical habitats, limiting overall carrying capacity and diversity in the population. Spawners waiting to access natal streams are susceptible to predation and other forms of mortality such as recreational fishing. Impacts to smolt outmigration and summer movement could also limit carrying capacity.

Methods:

Ratings were determined based on reviews of watershed reports, co-manager feedback, literature reviews, and best professional judgment. Conditions which were considered when rating this indicator include: (1) annual variability in passage, (2) seasonality of passage conditions, (3) severity of condition, and (4) geographic scope of problem.

Ratings:

The rating criteria were defined as follows:

Poor = <50% or <16 IP-km of historical IP-km accessible
Fair = 50% to 74% of historical IP-km habitat accessible
Good = 75% to 90% of historical IP-km accessible
Very Good = >90% of historical IP-km accessible

Ratings for Poor conditions addressed accessible proportions of the watershed, and the minimum threshold of potential habitat (expressed as IP-km) required for the population to be considered viable -in-isolation (20 IP-km for Chinook salmon, and 16 IP-km for steelhead). These thresholds assume populations historically operated close to the natural carrying capacity of the watershed.

Stress:

The stress associated with this indicator was Passage/ Migration: Mouth or Confluence & Physical Barriers. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect Passage/Migration.

2. Physical Barriers

Physical barriers are structures or sites preventing or impeding up- or downstream passage of migrating adult and juvenile salmonids.

The indicator was defined as the proportion of IP-km free of known barriers and thereby accessible to migrating salmonids. The physical barriers attribute included only total barriers which are complete barriers to fish passage for all anadromous species at all life stages at all times of year.

Methods:

SEC queried the Pacific States Marine Fisheries Council Passage Assessment Database (PSMFC 2006) to calculate the proportion of IP-km blocked to anadromy by impassable barriers. The PAD contains data and point file coverage for all known fish passage barriers. Each barrier in the database was identified as a full, partial or natural barrier. SEC evaluated only total or complete barriers to avoid overestimating actual impediments to migration.

In each population, the furthest downstream barrier was identified. SEC calculated the total IP-km lost per barrier. All lost IP-km were summed, and divided by the watershed IP-km for each population to yield the percent inaccessible IP-km.

Other passage impediments were also considered, such as estuary mouths closed by sandbars. These passage impediments were separated into their own attributes due to substantial differences in assessment methods. Natural barriers were not included in this attribute because they are already taken into consideration in the development of the IP networks. IP-km inadvertently included above natural barriers was removed from the IP-km network.

Large dams were evaluated as barriers because any IP reaches upstream of these barriers may have value to recovery. Spence *et al*. (2008) presented viable population targets both with and without IP-km above large dams. For some watersheds it may be possible to attain recovery goals without passage over these dams.

Ratings:

Rating criteria were defined as follows:

Poor = <50% or <16 IP-km of historical IP-km accessible
Fair = 50% to 74% of historical IP-km habitat accessible
Good = 75% to 90% of historical IP-km accessible
Very Good = >90% of historical IP-km accessible

Ratings for Poor conditions addressed accessible proportions of the watershed, and the minimum threshold of potential habitat (expressed as IP-km) required for the population to be considered viable -in-isolation (20 IP-km for Chinook salmon, and 16 IP-km for steelhead). These thresholds assume populations historically operated close to the natural carrying capacity of the watershed.

Stress:
The stress associated with this indicator was Passage/ Migration: Mouth or Confluence & Physical Barriers. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect Passage/Migration.

1.4.10 RIPARIAN VEGETATION

Riparian vegetation is all vegetation in proximity to perennial and intermittent watercourses potentially influencing salmonid habitat conditions. Riparian vegetation mediates a variety of biotic and abiotic factors interacting and influencing the stream environment. An adequately-sized riparian zone with healthy riparian vegetation filters nutrients and pollutants, creates a cool microclimate over a stream, provides food for aquatic organisms, maintains bank stability and provides hard points around which pools are scoured (Spence *et al.* 1996). NMFS (1996b) noted that "studies indicate that in Western states, about 80 to 90 percent of the historic(al) riparian habitat has been eliminated." NMFS considered three indicators when evaluating this attribute: (1) tree diameter-at-breast height (DBH), (2) canopy cover, and (3) riparian species composition.

1. Tree Diameter
Steelhead Target: Adults, Summer Rearing, Winter Rearing
Chinook Target: Adults, Pre Smolt

Intact riparian zones, often characterized by an adequate buffer of mature hardwood and/or coniferous forests, are an important component of a properly functioning habitat conditions for salmonids. The size and maturity of riparian buffers mediate upslope processes such as sediment delivery, provide shade which cools streams, and provide large wood to enrich habitat complexity.

Beardsley *et al*. (1999) used a diameter of 40 inches as indicative of old growth forests in the Sierra Nevada. The diameter of coastal riparian redwoods before disturbance may often have been several feet in diameter (Noss 2000). To provide properly functioning conditions the width of the riparian zone is equally important to the size of the trees. The zone of influence has been described to extend from one to two site potential tree heights (FEMAT 1993; Spence *et al.* 1996). Due to data limitations south of San Francisco, two ratings for this indicator were developed.

Methods:

The California Wildlife Habitat Relationships (CWHR) model[10] was used to determine predominant vegetation patterns and corresponding size class categories to estimate average tree size diameters within 100 meters of all IP-km. CWHR is an information system and predictive model for terrestrial species in California. The information in CWHR is based on current published and unpublished biological information and professional judgment by recognized experts on California's wildlife communities.

Various sources were compiled into the CWHR system classification. The dates for the source data range from 1970's (urban areas) to 2000. The bulk of the forest and rangeland data were collected by CalFire/USFS between 1994-1997. Alternative tree size criteria were initially considered when evaluating riparian stand condition. This alternative considered 100 meter wide riparian stands where more than 80 percent of the stand was comprised of trees with an average diameter at breast height (DBH) of 20 inches or greater to be an indicator of very good conditions. However, the 20-inch DBH criteria could not be used because the corresponding CWHR size class (size class 4) encompasses a wide range of tree diameters (11-23.9 quadratic mean diameter (QMD)). The range of CWHR size classes are outlined in Table 12. The large range rendered size class 4 an unsuitable proxy for the 20-inch DBH indicator. The difference in size and ecological function of a tree with an 11-inch QMD versus a 24-inch QMD is substantial, where an 11-inch QMD tree (depending on site conditions) is almost always younger (unless it is suppressed and/or located on poor soil types) and smaller (in height as well as diameter than a 24-inch QMD tree).

Table 12. CWHR Size Class Criteria.

CWHR Size Classes	CWHR Description	QMD
1	Seedling tree	< 1.0″
2	Sapling tree	1.0″ – 5.9″
3	Pole tree	6.0 – 10.9″
4	Small tree	11.0″ – 23.9″
5	Medium/large tree	≥ 24.0″
6	Multi-layered stand	A distinct layer of size class 5 trees over a distinct layer of size class 4 and/or 3 trees, and total tree canopy of the layers > 60% (layers must have > 10.0% canopy cover and distinctive height separation).

CWHR size classes were reviewed for watersheds considered to maintain properly functioning riparian condition in four locations: Smith River at Jedidiah Smith State Park, Redwood Creek in Redwood National Park, Prairie Creek, and the South Fork Eel River at Humboldt Redwoods State Park. In total, we reviewed CWHR size classes in

[10] For more information on the CWHR model, go to: http://ceic.resources.ca.gov/catalog/FishAndGame/WildlifeHabitatRelationshipsWHRSystem.html

the riparian zones of 95 miles of blue line streams (perennial and intermittent watercourses as identified by USGS) and used this information to establish criteria for reference conditions. These data indicated at least 70 percent of the 100 meter wide riparian zones were comprised of CWHR size class 5 and 6 forest. From these results we determined a 100 meter wide riparian buffer consisting, on average, of ≥ 70 percent CWHR size class 5 and 6 trees represented very good conditions in the northern diversity strata. Other size criteria (Good, Fair, and Poor conditions) were selected based on regional expertise while using the 70 percent threshold for very good conditions.

Rating 1: Tree Diameter (North of the Golden Gate), percent of riparian zones (100 meters from centerline of the active channel) in CWHR class 5 and 6
Tree diameter was used as an indicator of riparian function based on the average DBH of a stand of trees within a buffer that extends 100 meters back from the edge of the active channel.

Using CWHR information obtained from CalFire, GIS was used to evaluate riparian conditions across all IP-km in independent populations and all anadromous blue-line streams in dependent populations. Data on tree size classifications were available only for the populations north of the Golden Gate. Classes 5 and 6 are typically older, larger trees expected to contribute to good or very good ratings in the CAP and rapid assessments. They were rated as follows:

Poor = ≤ 39% CWHR size class 5 and 6 across IP-km;
Fair = 40% to 54% CHWR size class 5 and 6 across IP-km;
Good = 55% to 69% CWHR size class 5 and 6 across IP-km; and
Very Good = ≥ 70% CWHR size class 5 and 6 across IP-km.

Rating 2: Tree Diameter (South of the Golden Gate), CWHR density classes across blue line streams in population
For streams south of the Golden Gate, no comprehensive CWHR classification of the various size classes was available. CWHR data were compiled into CWHR density classes of conifer, conifer-hardwood, and hardwood woodland categories. Because these data lack a structural element, it was necessary to default to the CWHR density criteria as a proxy of riparian structure while acknowledging these data are not as robust as the diversity stratum north of the Golden Gate[11]. We compared the high density categories (conifer, conifer-hardwood, hardwood woodland) of the Santa Cruz area to the equivalent high density categories from the northern areas and determined

[11] NMFS analysts were familiar with riparian stand conditions in the Santa Cruz and San Mateo areas and those areas north of San Francisco Bay and overall tree species structure and composition in these areas. Staff determined Santa Cruz/San Mateo structure and composition generally comports to that in the northern diversity strata and was not comprised of inordinate proportions of dense stands of CWHR size class 1-3 trees.

conditions were good if ≥ 80 percent of the population had high density categories of conifer, conifer-hardwood, and/or hardwood woodland, on average in the riparian buffer for the watershed (population). This condition was described as 60 to 100 percent canopy closure; CWHR class D. For the Santa Cruz area, this indicator was rated using the percentages of size classes under density rating D to obtain the following total percentage for the size classes:

The indicator ratings were defined as follows:

Poor = ≤ 69% CWHR density rating D across IP-km;
Fair = 70% to 79% CHWR density rating D across IP-km;
Good = ≥ 80% CWHR density rating D across IP-km; and
Very Good = not defined.

Stress:
The stress associated with this indicator was Altered Riparian Species Composition & Structure. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect tree diameter.

2. <u>Canopy Cover</u>
Steelhead Target: Summer Rearing
Chinook Target: NA

Canopy cover is the percentage of stream area shaded by overhead foliage. Riparian vegetation forms a protective canopy, particularly over small streams by: (1) maintaining cool stream temperature in summer and insulating the stream from heat loss in the winter, (2) contributing leaf detritus, and (3) facilitating insect fall into the stream which supplements salmonid diets (Murphy and Meehan 1991). Reduction in canopy cover can change the stream environment and adversely affect salmonids by: (1) elevating temperature beyond the range preferred for rearing, (2) inhibiting upstream migration of adults, (3) increasing susceptibility to disease, (4) reducing metabolic efficiency, and (5) shifting of the competitive advantage of salmonids to non-salmonid species (Hicks *et al.* 1991b).

Methods:
Flosi *et al.* (2004) habitat typing survey methods use a spherical densitometer to estimate relative vegetative canopy closure or canopy density to provide an index of stream shading. Four measurements are taken from the middle of the stream, in four quadrants from the middle of a habitat unit (downstream, right bank, upstream, left bank). Typically, canopy is recorded in approximately every third habitat unit in addition to every fully-described unit. This provides an approximate 30 percent sub-sample for all habitat units. The sub-sample is expressed as an average for each stream reach. SEC queried the stream summary database for mean percent canopy cover for each stream reach and extrapolated these data to characterize each stream, for all streams within

each population (where survey data existed). Canopy closure at the stream scale was calculated from reach scale data, and aggregated by determining the percentage of streams/IP-km meeting optimal criterion at the population scale.

Ratings: Average canopy closure at the reach, stream and population scale
Flosi *et al.* (2004) recognized 80 percent canopy as optimal for salmonid habitat at a reach scale. Canopy closure varies inversely with stream order (as a function of channel width); thus, an average canopy closure of 70 percent was used to describe good conditions in CAP and rapid assessments. This accounts for the natural range of variability, and acknowledged bias in riparian shading estimates. Average stream canopy closure below 70 percent was rated progressively lower; average stream canopy above 80 percent was rated to identify refugia areas.

For the CAP and rapid assessments, indicator ratings were defined as follows:

Stream level rating criteria
Poor = < 50% average stream canopy;
Fair = 50% to 69% average stream canopy;
Good = 70% to 80% average stream canopy; and
Very Good = > 80% average stream canopy.

Each population was rated according to the following criteria:

Population level rating
Poor = < 50% of streams/IP-km rating good or better;
Fair = 50% to 74% of streams/IP-km rating good or better;
Good = 75% to 90% of streams/IP-km rating good or better; and
Very Good = > 90% of streams/IP-km rating good or better.

Stress:
The stress associated with this indicator was Altered Riparian Species Composition & Structure. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect canopy cover.

3. <u>Riparian Species Composition</u>
Steelhead Target: Watershed Processes
Chinook Target: Watershed Processes

Changes to the historical riparian vegetative community due to introduction of non-native plants or domination of early seral communities can adversely affect salmonid habitat. Invasive non-native plants such as *Arundo donax* can out-compete native plants and even form barriers to migration. Early seral species such as alder can suppress long lived conifers and significantly delay future large woody debris recruitment of these conifers. Hardwoods like alder do not form long lived woody debris elements as do conifers such as redwood and Douglas-fir.

Methods:
Historical vegetation status per population was difficult to obtain. We reviewed CalFire's database on major vegetation communities and determined major differences in historical vegetation species composition based on the percent of population in urban, agriculture, and herbaceous categories. Some inaccuracy likely exists with this approach because some urban areas and agricultural areas may have some riparian areas within the range of historical vegetation species composition. We assessed departure of riparian vegetation (within 100 meters of streams across IP-km) from historical conditions. However, based on the widths of the riparian buffers used in this assessment we believe the majority of the areas in these categories do not maintain the historical vegetation patterns.

Ratings:
Ecological status relates the degree of similarity between current vegetation and potential vegetation for a site or population. It can be measured on the basis of species composition within a particular community type or on the basis of community type composition within a riparian complex. Ratings were derived from Winward (1989) who developed criteria for potential natural communities.

Species composition is the presence and persistence (composition and structure) of the historical vegetative community within 100 meters of a watercourse within all IP-km of a population.

The indicator ratings were defined as follows:

Poor = < 25% historical riparian vegetation species composition;
Fair = 25% to 50% historical riparian vegetation species composition;
Good = 51% to 74% historical riparian vegetation species composition; and,
Very Good = ≥ 75% historical riparian species composition.

Stress:
The stress associated with this indicator was Altered Riparian Species Composition & Structure. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect riparian species composition.

1.4.11 Sediment

Sediment provides several important habitat functions for salmonids, including supporting spawning redds, delivering intergravel flows capable of delivering oxygen to incubating eggs, and supporting food production for rearing juveniles. Four indicators were used to evaluate the sediment component: (1) quantity and distribution of spawning gravel, (2) gravel quality (bulk and embeddedness), (3) gravel quality (food productivity – embeddedness), and (4) gravel quality (food productivity - D 50).

1. Quantity and Distribution of Spawning Gravels
Steelhead Target: Adults, Summer Adults
Chinook Target: Adults

The quantity and distribution of spawning substrate is the amount of spawning habitat available to the spawning population. Distribution indicates the degree of dispersion of spawning habitat across IP-km in a population.

Female salmonids usually spawn near the head of a riffle, just below a pool, where water changes from a laminar to a turbulent flow and where there is small to medium gravel substrate. The flow characteristics at the redd location usually ensures good aeration of eggs and embryos, and flushing of waste products. Water circulation in these areas facilitates fry emergence from the gravel. The lack of suitable gravel limits successful spawning in many streams.

Methods:
According to Meehan (1991), optimal conditions for spawning have nearby overhead and submerged cover for holding adults and emerging juveniles; water depth of 10 to 54 centimeters (cm); water velocities of 20 to 80 cm per second; clean, loosely compacted gravel (1.3 to 12.7 cm in diameter) with less than 20 percent fine silt or sand content; cool water (4° to 10° C) with high DO (8 mg/l); and an intergravel flow sufficient to aerate the eggs. To assess population conditions relative to these criteria, watershed reports, co-manager documentation and knowledge, and literature reviews to obtain quantitative data or estimates were used. Where quantitative data were lacking, a qualitative approach was used based upon best available information, spatial data and IP-km habitat potential to inform best professional judgment ratings.

Ratings:
Ratings were developed to spatially estimate the percentage of streams within each population meeting optimal spawning conditions. Optimal conditions are based on scientific literature. This condition was defined according to the following criteria:

Poor = < 50% IP-km meet optimal conditions;
Fair = 50% to 74% of IP-km meet optimal conditions;
Good = 75% to 90% of IP-km meet optimal conditions; and
Very Good = > 90% of IP-km meet optimal conditions.

Stress:
Because inadequate road crossings, grade control structures, or culverts often contribute to poor spawning gravel quantity or distribution by impeding normal sediment

transport, the stress associated with this indicator was Sediment Transport: Road Density. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect road conditions or density.

2. Gravel Quality (Embeddedness and Bulk Samples)
Steelhead Target: Summer Adults, Eggs,
Chinook Target: Eggs

Sediment, relative to its function as a key habitat attribute for the egg life stage, was defined as streambed gravels with particle size distribution of sufficient quality to allow successful spawning and incubation of eggs. These substrates must be located within spawning habitat defined by the IP-km model.

Methods:
Gravel quality was defined using two evaluation methods: embeddedness (Flosi *et al.* 2004) and bulk sampling (Valentine 1995). When bulk sampling data is available, the indicator is the portion of the sampled substrate consisting of > 0.85 millimeters and/or < 6.4 millimeters (NCRWQCB 2006). For Hab-8 data, gravel quality was defined as the distribution of embeddedness values.

SEC queried regional data sources for bulk sediment core sample (McNeil) surveys as the preferred method for evaluating gravel quality. However, few watersheds had data sufficient for a comprehensive analysis. In these circumstances, SEC used Hab-8 data from CDFW.

Rating 1:
SEC calculated the percentage of pool tail-outs within all IP-km with embeddedness values of 1, 2, 3, 4, or 5 and presented them as frequency distributions at the stream scale. A bias analysis was used to determine our degree of confidence in the data and to extrapolate the data to characterize each stream. Ratings were based on frequency distributions because embeddedness scores (1-5) are ordinal numbers; and cannot be averaged and used in the simple rating of Major Effect = > 2, Moderate Effect = 1 -2, and Minor Effect = < 1. Also, embeddedness estimates are visual and involve some subjectivity. Embeddedness estimates are not as rigorous as bulk gravel samples in describing spawning and incubation habitat conditions (KRIS Gualala[12]).

As described in Flosi *et al.*(2004), a score of 1 indicates substrate is less than 25 percent embedded; this is considered optimal salmonid spawning habitat. A score of 2 indicates 25-50 percent embedded and moderately impaired. A score of 3 indicates 50-75 percent

[12] http://www.krisweb.com/krisgualala/krisdb/html/krisweb/index.htm

embedded and highly impaired, 4 indicates 75-100 percent embedded and severely impaired, a 5 indicates the substrate is unsuitable for spawning. The embeddedness ratings used by Bleier *et al.* (2003) states the best spawning substrate is 0-50 percent embedded. CDFW's target value is 50 percent or greater of sampled pool tail-outs are within this range. Streams with less than 50 percent of their length in embeddedness values of 50 percent or less, are considered inadequate for spawning and incubation.

Typically, embeddedness ratings are recorded in every pool habitat unit, in addition to every fully-described unit which provides an approximate 30 percent sub-sample for all habitat units. This sub-sample is expressed as an average for each stream reach. Embeddedness rating criteria is based on criteria developed in the North Coast Watershed Assessment Program (Bleier *et al.* 2003):

Stream level embeddedness
Poor = <25% of the scores were rated as 1 or 2;
Fair = 25% to 50% of the scores were rated as 1 or 2;
Good = >50% of the scores were rated as 1 or 2; and
Very Good = Not defined.

The representative nature of the datasets was extrapolated to the overall population, for all streams within each population (where data were available). Rating each population required two steps; calculation of the average at the stream scale from the reach scale data, and determining the percentage of streams/IP-km meeting optimal criteria, at the population scale.

Each population was rated according to the following criteria:

Population level embeddedness
Poor = < 50% of streams/IP-km rating Good or better;
Fair = 50% to 74% of streams/IP-km rating Good or better;
Good = 75% to 90% of streams/IP-km rating Good or better; and
Very Good = > 90% of streams/IP-km rating Good or better.

Rating 2:
Rating criteria for percent of fines in low flow bulk samples from potential spawning sites were developed from a variety of sources, including the regional sediment reduction plans by the USEPA (1998; 1999) and the North Coast Regional Water Quality Control Board (2000; 2006) who developed a threshold of 0.85 mm for fine sediment with a target of less than 14 percent. NMFS (1996a) Guidelines for Salmon Conservation also used fines less than 0.85 millimeters as a reference and recognized less than 12 percent as properly functioning condition, 12-17 percent as at risk, and greater than 17 percent as not properly functioning. Fine sediments less than 11 percent are fully suitable, 11-15.5 percent somewhat suitable, 15.5-17 percent somewhat unsuitable and

over 17 percent fully unsuitable. McMahon (1983) found that egg and fry survival drops sharply when fines make up 15 percent or more of the substrate.

Based on these guidelines, rating criteria established a range of suitable gravel sizes for bulk samples:

> Poor = > 17% of gravels 0.85 mm or less and/ or > 30% of gravels < 6.4 mm;
> Fair = 15% to 17% of gravels 0.85 mm or less and/ or > 30% of gravels < 6.4 mm;
> Good = 12% to 14% of sediment 0.85 mm or less and/or > 30% of gravels < 6.4 mm; and
> Very Good = < 12% of sediment 0.85 mm or less and/ or > 30% of gravels < 6.4 mm

Stress:
The stress associated with this indicator was Sediment: Gravel Quality & Distribution of Spawning Gravels. This was compared against all threats except Disease/Predation/Competition, Fishing/Collecting and Hatcheries, which do not affect gravel quality.

3. <u>Gravel Quality (Food Production - Embeddedness)</u>
Steelhead Target: Summer and Winter Rearing
Chinook Target: Pre-Smolt, Smolts

We defined food productivity, relative to its function as a key habitat attribute for summer survival, as streambed gravels with particle size distribution of sufficient quality to facilitate productive macro-invertebrate communities. These substrates must be located within spawning habitat as defined by the IP-km model. Gravel quality was defined using embeddedness values from Hab-8 data.

Suttle *et al*. (2004) examined degraded salmonid spawning habitat, and its effects on rearing juveniles due to fine bed sediment in a northern California river. Responses of juvenile salmonids, and the food webs supporting them, showed increased concentrations of deposited fine sediment decreased growth and survival. Declines were associated with a shift from favorable invertebrates toward unfavorable invertebrates (burrowing taxa unavailable as prey). Fine sediment can transform the topography and porosity of the gravel riverbed and profoundly affect the emergent ecosystem, particularly during biologically active periods of seasonal low flow. Salmonid growth decreased steeply and roughly linearly with increasing fine sediment concentration.

Methods:

SEC queried CDFW Hab-8 data to rate this indicator. As described in Flosi *et al*. (2004), a score of 1 indicates substrate is less than 25 percent embedded; this is considered optimal salmonid spawning habitat. A score of 2 indicates 25-50 percent embedded and moderately impaired. A score of 3 indicates 50-75 percent embedded and highly impaired, 4 indicates 75-100 percent embedded and severely impaired, a 5 indicates the substrate is unsuitable. The percentage of pool tail-outs within all IP-km was calculated for embeddedness values, as discussed above, as a surrogate indicator for productive food availability for rearing juveniles.

Ratings:
Rating criteria for embeddedness are:

Stream level embeddedness
Poor = < 25% of the embeddedness scores were rated as 1 or 2;
Fair = 25% to 50% of the embededdness scores were rated as 1 or 2;
Good = > 50% of the embededdness scores were rated as 1 or 2; and
Very Good = Not defined.

The representative nature of the datasets was extrapolated to the overall population, for all streams within each population where the data existed to rate each population by determining the percentage of streams/IP-km met optimal criteria, at the population scale. Each population was rated according to the following criteria:

Population level rating criteria
Poor = < 50% of streams/IP-km rating Good or better;
Fair = 50% to 74% of streams/IP-km rating Good or better;
Good = 75% to 90% of streams/IP-km rating Good or better; and
Very Good = > 90% of streams/IP-km rating Good or better.

Stress:
The stress associated with this indicator was Sediment: Gravel Quality & Distribution of Spawning Gravels. This was compared against all threats except Disease/Predation/Competition, Fishing/Collecting and Hatcheries, which do not affect gravel quality.

4. <u>Gravel Quality (Food Production - D 50)</u>
Steelhead: Adults, Eggs, Summer Rearing, Winter Rearing
Chinook: NA

Knopp (1993) studied 60 northwestern California streams and determined a relationship between streambed median particle size (D50), and watershed disturbance. Reduced median particle size is often associated with increased sediment loads and increased bedload mobility (Montgomery and Buffington, 1993), which can cause egg and alevin mortality (Nawa *et al.* 1990). Increased peak flows resulting from watershed disturbance, particularly in the transient snow zone (Berris and Harr 1987), cause additional shear stress on the streambed and can result in an increase in D50 (Montgomery and Buffington 1993). All D50 survey data available, including those collected by Knopp (1993), are from low gradient response reaches as opposed to supply and transport reaches of steep and confined headwater channels.

Methods:
Knopp (1993) recognized a D50 of 38 mm or less as correlating with intensive watershed management. The U.S. Forest Service Pacific Northwest Forest and Range Experiment station has developed the Ecosystem Management Decision Support (EMDS) model (Reynolds 2001; Reeves *et al.* 2003) that rates habitat parameters in terms of their suitability for salmonids. Fully favorable median particle size distribution for salmonids according to EMDS falls within the range of 60-96 mm; partially favorable conditions extend from 45 mm to 60 mm and from 96 mm to 128 mm (Ward and Moberg 2004).

The rating criteria combine the EMDS rating curve and Knopp (1993):

Population level rating criteria for D50:
Poor = <38 mm and >128 mm
Fair = 38-50 mm and 110-128 mm
Good = 50-60 mm and 95-110 mm
Very Good = 60-95 mm

Stress:
The stress associated with this indicator was Sediment: Gravel Quality & Distribution of Spawning Gravels. This was compared against all threats except Disease/Predation/Competition, Fishing/Collecting and Hatcheries, which do not affect gravel quality.

1.4.12 Sediment Transport

Steelhead Target: Watershed Processes
Chinook Target: Watershed Processes

Sediment transport is the rate, timing, and quantity of sediment delivered to a watercourse. Because of their significant contribution to increased sediment in streams, two road related indicators were developed for this attribute. Construction of a road network can lead to greatly accelerated erosion rates in a watershed (Haupt 1959; Swanson and Dryness 1975; Swanson *et al.* 1976; Beschta 1978; Gardner 1979; Reid and Dunne 1984). Increased sedimentation in streams following road construction can be dramatic and long lasting. The sediment contribution per unit area from roads is often much greater than that from all other land management activities combined, including log skidding and yarding (Gibbons and Salo 1973). Sediment entering streams is delivered chiefly by mass soil movements and surface erosion processes (Swanston

1991). Failure of stream crossings, diversions of streams by roads, washout of road fills, and accelerated scour at culvert outlets are also important sources of sedimentation in streams (Furniss *et al.* 1991). Sharma and Hilborn (2001) found lower road densities (as well as valley slopes and stream gradients) were correlated with higher smolt density.

According to Furniss *et al*. (1991) "…roads modify natural drainage networks and accelerate erosion processes. These changes can alter physical processes in streams, leading to changes in streamflow regimes, sediment transport and storage, channel bank and bed configuration, substrate composition, and stability of slopes adjacent to streams. These changes can have important biological consequences, and they can affect all stream ecosystem components. Salmonids require stream habitats for food, shelter, spawning substrate, suitable water quality, and access for migration upstream and downstream during their life cycles. Roads can cause direct and indirect changes to streams that affect each of these components."

1. Road Density

Road density is the number of miles of roads per square mile of population. A series of data layers were used to calculate road density within each population. Two indicators were used to assess sediment transport: (1) road density and (2) streamside road density.

Methods:

GIS analysis of the miles of road networks within a population made use of several data sources:

1. CalFire Timber Harvesting History. GIS vector dataset, 1:24,000. 2007. Watersheds between Cottaneva Creek (inclusive) and the Russian River (inclusive);
2. CalTrans, Tana_rds_d04. GIS vector dataset, 1:24,000. 2007. Marin County watersheds;
3. U.S. Census Bureau, Roads. GIS vector dataset, 1:24,000. 2000. San Mateo County watersheds; and
4. County of Santa Cruz – Roads; Streets. GIS vector dataset, 1:24,000. 1999. Santa Cruz County watersheds.

The resulting linear measurement (in miles) was compared against the total population area in square miles to derive watershed (population) road density. The most inclusive datasets available for each population were used. The goal was to be as precise as possible for each population while acknowledging some inconsistency (due to the use of four datasets) may result from this approach.

Ratings:

Cederholm *et al*. (1980) found fine sediment in salmon spawning gravels increased by 2.6 - 4.3 times in watersheds with more than 4.1 miles of roads per square mile of land area. Graham Matthews and Associates (1999) linked increased road densities to increased sediment yield in the Noyo River in Mendocino County, California. King and Tennyson (1984) found the hydrologic behaviors of small forested watersheds were altered when as little as 3.9 percent of the watershed was occupied by roads. NMFS (1996a) guidelines for salmon habitat characterize watersheds with road densities greater than three miles of road per square mile of watershed area (mi/sq. mi) as "not properly functioning" while "properly functioning condition" was defined as less than or equal to two miles per square mile, with few or no streamside roads.

Armentrout *et al.* (1998) used a reference of 2.5 mi. of roads/sq. mi. as a watershed management objective to maintain hydrologic integrity in Lassen National Forest watersheds harboring anadromous fish. Regional studies from the interior Columbia River basin (USFS 1996) show that bull trout do not occur in watersheds with more than 1.7 miles of road per square mile. The road density rating system shown in Figure 4 was developed based on the Columbia basin findings (USFS 1996).

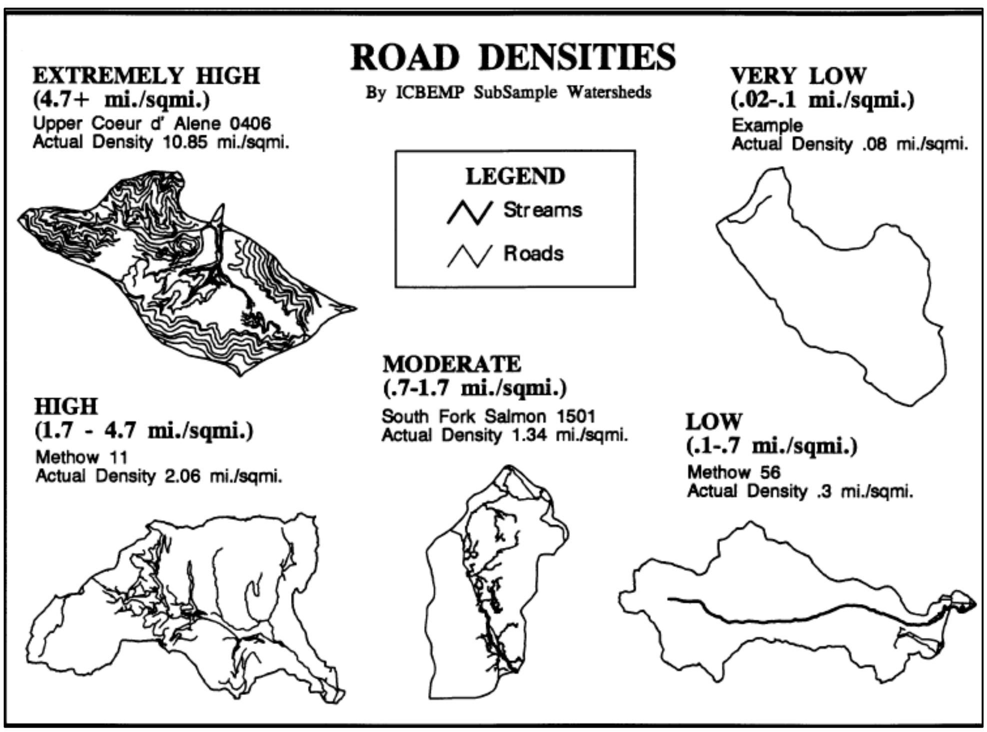

Figure 4. Graphic from the Interior Columbia Basin Management Plan, showing classes of road densities for sample watersheds (USFS, 1996).

The resulting road density rating criteria was:

Poor = > 3 miles/square mile of population
Fair = 2.5 to 3 miles/square mile of population
Good = 1.6 to 2.4 miles/square mile of population
Very Good = < 1.6 miles/square mile of population

Stress:
The stress associated with this indicator was Sediment Transport: Road Density. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect road density.

2. Streamside Road Density

Streamside road density is the density of roads, per square mile of a 200 meter riparian corridor (100 meters on either side of the stream centerline) within the population.

Roads frequently constitute the dominant source of sediments delivered to watercourses. Roads constructed within the riparian buffer zone pose many risks to salmonid habitat including the loss of shade, decreased large wood recruitment, and delivery of fine sediment and initiation of mass wasting (Spence *et al*. 1996). Rock revetments are often used to prevent streams from eroding road beds, resulting in channel confinement that can lead to incision of the stream bed. Roads in close proximity to watercourses may have a greater number of crossings which may act as: (1) impediments to migration, (2) flow restrictions which artificially change channel geometry, and (3) sources of substantial sediment input due to crossing failure.

Methods:
The most inclusive datasets available for each population were used. The goal was to be as precise as possible for each population while acknowledging some inconsistency (due to the use of several different datasets) may result from this approach.

A series of GIS data layers were used to calculate the riparian buffer and road density within each dependent and independent population:

To create the riparian buffer these stream files were used:

1. Streams - CalFire, Hydrography Watershed Assessment; Wahydro. GIS vector dataset, 1:24,000. 1998. Watersheds from Cottaneva Creek (inclusive) to the Russian River (inclusive); and
2. Streams - USGS National Hydrography Dataset; Flowline (1801, 1805), vector digital dataset, 1:24,000. 2004. Watersheds in Marin, San Mateo, and Santa Cruz counties.

To create the road layer these stream files were used:

1. CalFire Timber Harvesting History. GIS vector dataset, 1:24,000. 2007. Watersheds between Cottaneva (inclusive) and the Russian River (inclusive);
2. CalTrans, Tana_rds_d04. GIS vector dataset, 1:24,000. 2007. Marin County watersheds;
3. U.S. Census Bureau, Roads. GIS vector dataset, 1:24,000. 2000. San Mateo County watersheds; and

4. County of Santa Cruz – Roads; Streets. GIS vector dataset, 1:24,000. 1999. Santa Cruz County watersheds.

Ratings:
The USFS (2000) provides data for near stream roads in road miles per square mile and a frequency distribution was used to derive values showing very low relative risk as very good (<0.1 mi/sq. mi) and the opposite end of the frequency spectrum as posing high relative risk to adjacent habitat as poor (> 1 mi/sq. mi).

The resulting road density within 100 meters of the watercourse (centerline) rating criteria was:

Poor = > 1 mile/square mile of riparian corridor;
Fair = 0.5 to 1 mile/square mile of riparian corridor;
Good = 0.1 to 0.4 mile/square mile of riparian corridor; and
Very Good = < 0.1 mile/square mile of riparian corridor.

Stress:
The stress associated with this indicator was Sediment Transport: Road Density. This was compared against all threats except Fishing/Collecting and Hatcheries, neither of which affect road density.

1.4.13 SMOLTIFICATION

Steelhead Target: Smolts
Chinook Target: Smolts

This attribute focused on temperature criteria required during the physiological changes young salmonids undergo in preparation to enter the ocean (smoltification) and potential anthropogenic sources which lead to alterations in stream water temperature. While the smoltification process can occur throughout the wet season, most salmonids smolt and emigrate to the ocean during the spring months (specific emigration periods vary between and among species and across the geographic range). Naturally occurring warmer water temperatures (such as those that may occur in streams within the southern extent of the NCCC Domain or where solar radiation occurs naturally) were distinguished from temperature impairments due to human induced alterations.

The extent and magnitude of spatial and temporal temperature variations within emigration routes was considered when evaluating potential impacts. For example, where access to cold water refugia is lost, the length of warm water exposure was considered with respect to behavior alteration and/or physiological impairment during smoltification.

Methods:
A literature review was conducted to identify sources of temperature information, and evaluate temperature thresholds necessary to support and to avoid delays in smoltification and emigration. Examples of anthropogenic sources of in-stream temperature alteration to be considered include, but are not limited to:

1. Off channel pond discharges;
2. On-channel pond complexes;
3. Agricultural land discharges;
4. Dams and reservoirs (USEPA 2003);
5. Riparian clearing that reduces canopy cover and increases instream solar warming;
6. Water withdrawals (USEPA 2003);
7. Channeling, straightening or diking (USEPA 2003); and
8. Removing upland vegetation or creating impervious surfaces (USEPA 2003).

Ratings:
In considering anthropogenically altered water temperature regimes and effects on smoltification and emigration, location, extent, magnitude (significance of temperature alteration), and duration of the effects were evaluated. The rating criteria considered the following factors:

- Magnitude of temperature alteration (*i.e.*, how much does the temperature deviate from natural stream water temperatures or from preferred criteria);
- Relative percent of rearing habitat, or relative percent of the emigrating population affected by anthropogenically altered temperature regimes;
- Relative location and extent of the affected reaches within the population (*i.e.*, the importance of the individual reach to the population); and
- The duration these effects persist (including effects on diel temperature fluctuations).

Because most temperature data is recorded at specific points within a watershed, data were extrapolated to rate the population level. For example, a large anthropogenic temperature alteration low in the mainstem of a watershed could be considered fairly significant in affecting not only the reach in which the alteration occurs, but for the entire population, since emigrating smolts from the upstream reaches will have to pass through the affected downstream reaches.

For rating the population, optimal conditions are described as temperatures > 6° C but < 16° C (expressed as maximum weekly maximum temperature (MWMT)), and/or anthropogenic thermal inputs/alterations that do not affect smoltification or emigration.

Temperature rating criteria are:

Poor = < 50% IP-km with temperatures > 6° and < 16° C;
Fair = 50% to 74% IP-km with temperatures > 6° and < 16° C;
Good = 75% to 90% IP-km with temperatures > 6° and < 16° C; and
Very Good = > 90% IP-km with temperatures > 6° and < 16° C.

Stress:
The stress associated with this indicator was Water Quality: Temperature. This was compared against all threats except Fishing/Collecting which does not affect smoltification.

1.4.14 VELOCITY REFUGE: FLOODPLAIN CONNECTIVITY

Steelhead Target: Adults, Winter Rearing, Summer Adults
Chinook Target: Adults, Pre-Smolt, Smolts

Velocity refuge is habitat providing space and cover for adult and juvenile salmonids during high velocity flood flows. Stream complexity that creates low velocity areas during high flow events, whether from LWD, off-channel habitats such as alcoves, backwaters, or floodplains, is an important component of winter rearing habitat. (Bustard and Narver 1975; Bell *et al.* 2001). Floodplains are geomorphic features frequently inundated by flood flows, and often appear as broad flat expanses of land adjacent to channel banks. Floodplain connectivity is floodplain inundation in unconfined reaches.

Frequencies of inundation approximating an unaltered state retain the ability to support the emergent ecological properties associated with floodplain connectivity.
Periodic inundation of floodplains by storm flows provides several ecological functions beneficial to salmon, including: coarse sediment sorting, fine sediment storage, groundwater recharge, velocity refuge, formation and maintenance of off-channel habitats, and enhanced forage production (Stanford *et al.* 2004). Floodplain connectivity is associated with more diverse and productive food webs (Power *et al.* 1996). Channel incision, bank stabilization, channelization, and urban development can result in the reduction or elimination of access to floodplain habitats (Power *et al.* 1996). Salmonids use such off-channel habitats during winter for refuge during high flow events and floodplains for feeding during early spring and summer.

Methods:
This indicator was assessed by quantifying the degree of urbanization, channelization, incision and other factors affecting flood-prone areas for each population. Federal Emergency Management Agency's (FEMA) delineation of Zone A Flood Zone Designation maps assisted this interpretation in the definition of flood-prone areas.

NMFS' watershed characterization maps and statistics also assisted to describe the degree of urbanization and other land uses impacting floodplains such as agriculture.

The USFS (2000) Region 5 watershed condition rating system is aimed at maintaining "…the long-term integrity of watersheds and aquatic systems on lands the agency manages" (Table 13). Among other features, it specifically addresses floodplain connectivity. A response reach is a stream reach that adjusts to changes in flow and sediment loads by changing its morphology. Changes can include widening or narrowing, straightening or increasing sinuosity, incising, aggrading, etc. Generally, response reaches have erodible bed and bank material, and they tend to be flatter than transport reaches. When upstream sediment inputs increase, sediment tends to deposit in response reaches

Table 13. U.S. Forest Service Region 5 Watershed Condition descriptions (USFS 2000).

Indicator	Fully Functional	Partially Functional	Impaired
Stream Corridor Vegetation	No more than 10% of riparian in less than proper functioning condition. No disturbance to less than 5% of streamside zone.	Between 10-25% of the stream corridor area vegetation not meeting properly functioning condition. From 5-10% recent disturbance.	More than 25% of the riparian zone not in proper functioning condition. More than 10% has experienced recent disturbance.
Floodplain Connectivity	Greater than (80%) response reaches and parts of response reaches within the watershed demonstrate floodplain connectivity	Only some (50-80%) response reaches have inundation of historic floodplains by bankfull flows.	Few (<50%) response channels in the watershed display floodplain connectivity.
Water Quantity/Flow Regime	Hydrograph has no alteration from natural conditions. Flows support availability of aquatic habitat.	The timing, rate of change and/or duration of mid-range discharges may impair aquatic habitat availability but peaks and low flows remain unaltered.	Peak flows and low flows significantly depart from a natural hydrograph impairing aquatic habitat availability and/or resulting in changes to channel morphology.

The USFS considers channel condition to be properly functioning when more than 80 percent of the low gradient response reaches have floodplain connectivity, while 50-80 percent was considered partially functional and less than 50 percent non-functional. NMFS analysts rated watersheds using that system. Ratings were based on FEMA delineation maps, watershed reports, co-manager documentation, literature reviews, and best professional judgment. Where quantitative data was lacking, a qualitative approach was utilized using the best available literature, spatial data and IP-km habitat potential to inform best professional judgment ratings.
Rating criteria are as follows:

Poor = < 50% response reach connectivity;

Fair = 50% to 80% response reach connectivity;
Good = > 80% response reach connectivity; and
Very Good = Not defined.

Stress:
The stress associated with this indicator was Velocity Refuge: Floodplain Connectivity. This was compared against all threats except Fishing/Collecting and Hatcheries which do not affect the indicator.

1.4.15 VIABILITY

This attribute addresses a suite of demographic indicators defining population status and provides an indication of their extinction risk. McElhany *et al.* (2000) developed criteria to determine what constitutes a viable population. Each viable population was then categorized according to the following extinction risk categories: abundance, population growth rate, population spatial structure, and population diversity.

The viability attribute is a population metric and, in conjunction with habitat attributes, provides a means to validate assumptions and conclusions. For example, if habitat quality was rated as good, and fish density or abundance was poor, it provided a basis to re-evaluate conclusions and examine assumptions about causative relationships between populations and habitat. For most populations, little or no data exist. Thus, staff used their best professional judgment to rate three indicators of viability: (1) spatial structure, (2) density, and (3) abundance. The rapid assessment analyses used a modified approach for determining abundance.

1. Spatial Structure
Steelhead Target: Summer Rearing
Chinook Target: Adults, Pre-Smolt

Population spatial structure describes how populations are arranged geographically based on dispersal factors and quality of habitats. Current distribution of the population occupying available habitat is one of the four key factors in determining salmonid population persistence (McElhany *et al.* 2000). Species occupying a larger proportion of their historical range have an increased likelihood of persistence (Williams *et al.* 2007). To evaluate current distribution the historical range (IP-km) was compared to the percentage of habitat currently occupied.

Methods
CDFW, NMFS, and other agency and organization surveys, data sources and reports were used in evaluating the percentage of historical habitat currently occupied by the species. Population characterization maps were compared with IP-km maps to provide a spatial representation to estimate the percentage of the historical range currently occupied.

Ratings:
The following indicator ratings of habitat currently occupied were developed by Williams *et al.* (2006) for a similar conservation assessment described in Williams *et al.* (2007):

> Poor = < 50% of historical range;
> Fair = 50% to 74% of historical range;
> Good = 75% to 90% of historical range; and
> Very Good = > 90% of historical range.

Stress:
The stress associated with this indicator was Viability: Density, Abundance & Spatial Structure. This was compared only against the threats that had a direct effect on viability. These include: Disease/Predation/Competition, Fishing/Collecting, Hatcheries, and Water Diversion and Impoundments.

2. <u>Density</u>
Steelhead Target: Adults, Summer Rearing
Chinook Target: Adults

Density estimates that are consistently low within a watershed may suggest that the watershed is not functioning properly. High density estimates suggest a watershed is properly functioning and can be used by fishery managers to prioritize threat abatement efforts. Density was evaluated for both summer rearing and adult life stages; however these required different rating methods.

Methods:
Density was used as an indicator for the adult life-stage because it is one of the principle metrics used to define population viability in the biological viability report (Spence *et al.* 2008) developed by the Technical Recovery Team (TRT).

Assessing juvenile density provides a relative indication of species presence and carrying capacity. The juvenile density indicator was informed through a review of the literature including CDFW reports, NMFS technical memorandums, watershed analyses, ESA section 10 research permit reports, and fisheries management and assessment reports. Co-managers were also interviewed. The information was compiled and synthesized by NMFS biologists (with extensive field experience) who used best professional judgment to rate the density.

Rating 1:

The TRT established criteria of one spawning adult per IP-km as a reasonable threshold to indicate a population at high risk of depensation[13]. This threshold was used as an indicator for a Poor spawner density.

The TRT also developed density criteria for population viability. For the smallest of independent populations (*i.e.*, those with 16 IP-km for steelhead and 20 IP-km for Chinook), adult spawning densities should exceed 40 fish per IP-km to achieve viability. Densities may decrease to 20 fish per IP-km as the size of an independent population approaches ten times the minimum size (*i.e.,* 160 IP-km and 200 IP-km for steelhead and Chinook respectively). This formula was applied to both independent and dependent populations and used as our criteria for a good rating (Table 14 and Table 15). Fair rating was any density between poor and good. A criterion rating for very good was not established.

Table 14. Examples of adult density (# of adults/IP-km) criteria for select NC and CCC steelhead populations from TRT adult abundance criteria (Spence *et al*. 2008).

Population	Poor	Fair	Good	Very Good
Mattole River	≤1	2-19	≥20	None
Upper Main Eel	≤1	2-27	≥28	None
Chamise Creek	≤1	2-36	≥37	None
Tomki Creek	≤1	2-23	≥24	None
Bucknell Creek	≤1	2-38	≥39	None
Ten Mile River	≤1	2-19	≥20	None
Casper Creek	≤1	2-39	≥40	None
Austin Creek	≤1	2-26	≥27	None
Salmon Creek	≤1	2-32	≥33	None
Walker Creek	≤1	2-28	≥29	None
Lagunitas Creek	≤1	2-29	≥30	None
Pilarcitos Creek	≤1	2-39	≥40	None
Guadalupe River	≤1	2-24	≥25	None
San Francisquito	≤1	2-36	≥37	None
Petaluma River	≤1	2-39	≥40	None
Alameda Creek	≤1	2-36	≥37	None
San Gregorio Creek	≤1	2-30	≥31	None
Pescadero Creek	≤1	2-28	≥29	None
Waddell Creek	≤1	2-39	≥40	None
Scott Creek	≤1	2-38	≥39	None

[13] At very low densities, spawners may find it difficult to find mates, small populations may be unable to saturate predator populations, and group dynamics may be impaired, *etc*. Small populations may experience a reduction in per-capita growth rate with declining abundance, a phenomenon known as depensation (Spence *et al*. 2008).

Table 15. Examples of adult density (# of adults/IP-km) criteria for select NC and CCC steelhead populations from TRT adult abundance criteria (Spence *et al*. 2008).

Population	Poor	Fair	Good	Very Good
Redwood Creek	≤1	2-28	≥29	None
Mad River	≤1	2-31	≥32	None
Lower Eel River	≤1	2-19	≥20	None
Upper Eel River	≤1	2-19	≥20	None
Mattole River	≤1	2-22	≥23	None
Noyo River	≤1	2-34	≥35	None
Big River	≤1	2-30	≥31	None
Russian River	<1	2-19	>20	None
Garcia River	≤1	2-22	≥23	None
Gualala River	≤1	2-38	≥39	None

To assess the indicator by watershed, the estimated current annual spawning population (N_a) was divided by the amount of IP-km available for spawning (N_a/IP-km). N_a was measured as the geometric mean of annual spawner abundance for the most recent three to four generations (Spence *et al.*, 2008). The TRT evaluated current abundance for all independent populations in the ESU/DPS and found data availability was insufficient in most cases. We therefore made reasonable inferences based on what information was available. Data sources we used for this assessment included the NMFS Southwest Fisheries Science Center database, NMFS' recovery library, and previous status assessments (Good *et al.* 2005).

Rating 2:

Although methods for estimating the population abundance of salmonids have been developed (Hankin and Reeves 1988), there are few estimates for populations within the NCCC Domain. Estimates of juvenile density, however, are more common and provide some indication of life-stage-specific status. Assessing juvenile density provides a relative indication of species presence and carrying capacity. Density estimates may also be useful in indicating habitat quality if streams are adequately seeded (with adequate fish per unit area).

Rating criteria for juvenile density were based on the assumption that approximately 1.0 fish per square meter is a reasonable benchmark for fully occupied, good habitat (Nickelson *et al.* 1992; Solazzi *et al.* 2000). Ratings are as follows:

Poor = < 0.2 fish/meter^2;
Fair = 0.2 to 0.5 fish/meter^2;
Good = 0.5 to1.0 fish/meter^2; and

Very Good = > 1.0 fish/meter^2

Stress:
The stress associated with this indicator was Viability: Density, Abundance & Spatial Structure. This was compared only against the threats that had a direct effect on viability. These include: Disease/Predation/Competition, Fishing/Collecting, Hatcheries, and Water Diversion and Impoundments.

3. <u>Abundance for CAP Analysis</u>
Steelhead Target: Smolts, Summer Adults
Chinook Target: Smolts

Abundance of the population occupying available habitat is one of the four key factors in determining salmonid population persistence (McElhany *et al.* 2000). Abundance is the number of adult spawners measured over time based on life history. We use abundance as an indicator not only because it is a direct measure of population size, but because smolt populations can be estimated with various out-migrant trapping and mark and recapture methods. Abundant species have an increased likelihood of persistence over time, and a lower risk of extinction.

Rating 1:
We used the following equation to calculate the number of smolts (at time *t*) needed to satisfy the abundance criteria defined by the TRT (S_t):

$$S_t = \frac{A_{t+i}}{0.01_i}$$

Where A_{t+1} is the adult abundance after time interval (*i*) divided by the assumed marine survival of 1% during time interval *i.* Therefore, to calculate smolt abundance criteria for each population, good criteria would be the "low risk abundance" (the adult target representing a low risk of extinction over time as defined in Spence *et al.* (2008) divided by 0.01); and poor criteria would be the "high risk abundance" (the adult target representing high risk of extinction as defined in Spence *et al.* (2008) divided by 0.01). Fair criteria would be abundance levels between low risk and high risk. For example, for the Noyo River this calculation yields the following rating (Table 16).

Table 16. Example of indicator criteria for smolt abundance Noyo River steelhead calculated from TRT adult abundance criteria.

Smolt Abundance	Poor	Fair	Good
	High Risk	Moderate Risk	Low Risk
Noyo River	<19,700	19,700- 390,000	>390,000

To assess the status of smolt production for a given watershed available monitoring data, most of which is contained in data sources such as the NMFS Southwest Fisheries Science Center database, NMFS recovery library, and previous status assessments (Good *et al.* 2005) were relied on. When no population estimates were currently available for the smolt life stage (or any other), we reviewed the data sources and made reasonable inferences as to the probable status of smolts.

Rating 2:
To assess the abundance of summer adult steelhead, criteria outlined in Spence *et al*. (2008) were applied. These criteria set the low risk spawner density based on a calculation of available IP-km. Rating criteria were developed as follows:

Poor = < 1 fish/IP-km;
Fair = >1 fish/IP-km to < low risk density
Good = low risk density

A criterion rating for very good abundance was not established.

Stress:
The stress associated with this indicator was Viability: Density, Abundance & Spatial Structure. This was compared only against the threats that had a direct effect on viability. These include: Disease/Predation/Competition, Fishing/Collecting, Hatcheries, and Water Diversion and Impoundments.

4. Abundance for Rapid Assessment Analysis

At very low densities populations experience a reduction in per capita growth rate with declining abundance, a phenomenon referred to as depensation. Populations are at a heightened risk of extinction due to depensation. Factors can include reduced probability of finding mates, inability to saturate predator populations, impaired group dynamics, and loss of environmental conditioning. Using depensation information, we developed abundance targets for populations not selected in recovery scenarios to attain a viable status and dependent populations that are inherently non-viable.

Spence *et al*. (2008) defines depensation at which populations are at a high risk of extinction where a population has an average spawner density of less than 1 adult spawner per IP km. Spence *et al.* (2008) notes, however, that various other authors suggest thresholds ranging from 1 to 5 spawners per IP-km (Chilcote 1999; Sharr *et al.* 2000; Barrowman *et al.* 2003; Wainwright *et al.* 2008) (Table 17). Extinction risk is high for populations with these densities due in large part to depensation conditions. Best available information suggests populations supporting more than 5 spawners per IP-km are unlikely to experience depensation and 12 spawners per IP-km highly unlikely to experience depensation (Wainwright *et al.* 2008). Thus, a range of 6-12 spawners per IP-km for connectivity populations was chosen to diminish depensation as a factor effecting these populations.

Table 17. Suggested depensation thresholds by various authors.

Source	Depensation Threshold	Likelihood of Depensation
Chilcote 1999	2.4 Spawners/IP km	Unlikely to recover
Sharr 2000	3.1 Spawners/IP km	High extinction risk
Barrowman 2003	2 Spawners/IP km	Depensation
Wainwright 2008	2.5 Spawners/IP km	Depensation Very Likely
	6 Spawners/IP km	Highly Unlikely
	12 Spawners/IP km	Not Likely

Ratings:
See Volumes II, III, and IV for spawner targets for each population. Rating criteria are as follows:

Poor = <2 spawners/IP-km
Fair = 2-6 spawners/IP-km
Good = 6-12 spawners/IP-km
Very Good = >12 spawners/IP-km

Stress:
The stress associated with this indicator was Viability: Density, Abundance & Spatial Structure. This was compared only against the threats that had a direct effect on viability. These include: Disease/Predation/Competition, Fishing/Collecting, Hatcheries, and Water Diversion and Impoundments.

1.4.16 WATER QUALITY

Water quality was assessed to classify three indicators: (1) water temperature, (2) toxicity, and (3) turbidity. In addition, several measures for aquatic invertebrates were used to assess streams where such data existed.

1. Water Temperature (Maximum Weekly Maximum Temperature (MWMT))
Steelhead: Summer Rearing, Smolts, Summer Adults
Chinook: Pre Smolt

Water temperature is an important indicator of water quality, particularly with respect to juvenile salmonids, because the species is sensitive to temperature conditions.

Juvenile salmonids respond to stream temperatures through physiological and behavioral adjustments that depend on the magnitude and duration of temperature exposure. Acute temperature effects resulting in death are associated with exposures ranging from minutes to 96 hours. Chronic temperature effects are those associated with exposures ranging from weeks to months. Chronic effects are generally sub-lethal and may include reduced growth, disadvantageous competitive interactions, behavioral changes, and increased susceptibility to disease (Sullivan *et al.* 2000). We used a measure of chronic temperature because it is more typical of the type of stress experienced by summer rearing juveniles.

Methods:
Temperature thresholds for chronic exposure are typically based on the Maximum Weekly Average Temperature (MWAT) metric. Due to some confusion in the literature regarding the appropriate definition and application of MWAT, we used the seven day moving average of the daily maximum (7DMADM or MWMT) indicator, rather than the seven day moving average of daily average (7DMADA or MWAT), because it correlated more closely with observed juvenile distribution (Hines and Ambrose 2000)(Hines and Ambrose 2000)(Hines and Ambrose 2000)(Hines and Ambrose 2000)(Hines and Ambrose 2000)(Hines and Ambrose 2000)(Hines and Ambrose 2000)(Hines and Ambrose 2000)(Hines and Ambrose 2000). However, where MWMT data was not available, MWAT was used. We established two sets of rating criteria where the calculation for MWMT was two degrees Celsius higher than the MWAT.

To assess conditions throughout each watershed, it was necessary to evaluate temperature conditions throughout all potential rearing areas (*i.e.,* across all IP-km). We established a method for spatializing site-specific watershed temperature data by plotting these data on a map of the IP network for each species. Each data point was color coded to indicate the temperature threshold the site exceeded (*i.e.,* sites with MWMT >20° C were colored red, *etc*.). For locations with multiple years of data, we averaged the MWMT or MWAT and indicated the number of years of data and standard deviations. The temperatures were extrapolated to IP reaches using our understanding of typical spatial temperature patterns and staff knowledge of specific watershed conditions. For NC steelhead summer adults, since no IP network exists, only mainstem streams where adults were found were analyzed. Finally, where temperature data was limited or absent, we used best professional judgment and assigned a low confidence rating to the results.

Ratings:
Juvenile salmonids prefer water temperatures of 12° C to 15° C (Brett 1952; Reiser and Bjornn 1979), but not exceeding 22° C to 25° C (Brungs and Jones 1977)) for extended time periods. Chronic temperatures, expressed as the maximum weekly average temperature, in excess of 15° C to 18° C are negatively correlated with salmonid presence (Hines and Ambrose 2000; Welsh *et al.* 2001). Sullivan *et al.* (2000)

recommended a chronic temperature threshold of 16.5° C for this species. Water temperatures for good survival and growth of juvenile salmonids range from 10 to 15° C (Bell 1973; McMahon 1983). Growth slows considerably at 18° C and ceases at 20° C (Stein *et al.* 1972; Bell 1973). The likelihood of juvenile salmonids occupying habitats with maximum weekly average temperatures exceeding 16.3° C declined significantly (Welsh *et al.* 2001) in the Mattole River watershed in southern Humboldt County, California. Optimal temperatures for both Chinook salmon fry and juveniles range from 12-14 °C, with maximum growth rates at 12.8 °C (Boles 1988). While rearing, optimal temperatures for steelhead growth range between 12 and 19 ° C (Hokanson *et al.* 1977; Wurtsbaugh and Davis 1977; Moyle 2002; Myrick and Cech 2005).

Temperature thresholds for chronic exposure are typically based on the Maximum Weekly Average Temperature (MWAT) metric. Due to some confusion in the literature regarding the appropriate definition and application of MWAT, we used the seven day moving average of the daily maximum (7DMADM or MWMT) indicator, rather than the seven day moving average of daily average (7DMADA or MWAT), because it correlated more closely correlated with observed juvenile distribution. However, where MWMT data was not available, MWAT was used. We established two sets of rating criteria where the calculation of for MWMT was two degrees Celsius higher than the MWAT.

Welsh *et al.* (2001) note that transitory water temperature peaks can be harmful to salmonids and are better reflected by the maximum floating weekly maximum water temperature (MWMT). ODFW uses an MWMT value of 64 degrees F as protective of water quality, which is similar to the finding of Welsh *et al.* (2001).

Steelhead Population level temperature rating criteria are:

Poor = <50% IP-km (<20° C MWMT)*
Fair = 50 to 74% IP-km (<20° C MWMT)*
Good = 75 to 90% IP-km (<20° C MWMT)*
Very Good = >90% IP-km (<20° C MWMT)*

*or (<16 C MWMT) where CCC steelhead and CCC coho co-exist, or (<18.1 C MWMT) where NC steelhead and SONCC coho co-exist

Chinook Population level temperature ratings are:

Poor = <50% IP-km (>6° and < 14° C MWMT)
Fair = 50 to 74% IP-km (>6° and < 14° C MWMT)
Good = 75 to 90% IP-km (>6° and < 14° C MWMT)
Very Good = >90% IP-km (>6° and < 14° C MWMT)

Stress:
The stress associated with this indicator is Water Quality: Temperature. This was compared against all threats except Fishing/Collecting which does not affect the indicator.

2. <u>Turbidity</u>

Steelhead: Adults, Summer Rearing, Winter Rearing, Smolts
Chinook: Adults, Pre Smolt, Smolts

Research has demonstrated highly turbid water can adversely affect salmonids, with harmful effects as a direct result of suspended sediment within the water column. The mechanisms by which turbidity impacts stream-dwelling salmonids are varied and numerous. Turbidity of excessive magnitude or duration reduces feeding efficiency, decreases food availability, impairs respiratory function, lowers disease tolerance, and can also directly cause fish mortality (Cordone and Kelley 1961; Berg and Northcote 1985; Gregory and Northcote 1993; Velagic 1995; Waters 1995; Harvey and White 2008). Mortality of very young salmonids due to increased turbidity has been reported by Sigler *et al.* (1984). Even small pulses of turbid water can cause salmonids to disperse from established territories (Waters 1995), which can displace fish into less suitable habitat and/or increase competition and predation, decreasing chances of survival.

Methods:
Turbidity indicators focused on suspended sediment concentration and duration of exposure. To document the relationship between dose (the product of turbidity and exposure time) and the resultant biological response of fish, Newcombe (2003) reviewed existing data to develop empirical equations to estimate behavioral effects from a given turbidity dose. For juvenile and adult salmonids, the expected behavioral response and severity of ill effects (SEV) is illustrated in Figure 5 (from Newcombe 2003). Using turbid conditions that score a 4 SEV or higher during any time scale along the x-axis represent conditions likely limiting juvenile salmonid survival. Conversely, a score of 3 SEV or lower represent conditions favoring survival to the next life stage. NMFS analysts followed the SEV scoring method to determine the impact of turbidity for each population.

Visual clarity of water (yBD) and related variables | **Duration of exposure to conditions of reduced VISUAL CLARITY ($\log_e$ hours)** | **Fish reactive distance:** *calibrated for trout*

Severity-of-ill-effect Scores (SEV) -- Potential

$$SEV = -4.49 + 0.92 (\log_e h) - 2.59 (\log_e yBD)$$

alternate		*preferred*																
				log_e hours:	0	1	2	3	4	5	6	7	8	9	10			
NTU	zSD (m)	BA (m^{-1})	yBD (m)													ψ_{BD} (cm)	xRD (cm)	
				Δ_{15}	Δ_{16}	Δ_{17}	Δ_{18}	Δ_{19}	Δ_{20}	Δ_{21}	Δ_{22}	Δ_{23}	Δ_{24}	Δ_{25}				
1100	0.01	500	0.010	Δ_{14}	7	8	9	10	11	12	13	14				1	-	O
			0.014	Δ_{13}	7	7	8	9	10	11	12	13	14			1	-	N
400	0.03	225	0.02	Δ_{12}	$_{P}6^{\pi}$	7	7	8	9	10	11	12	13	14		2	-	M
			0.03	Δ_{11}	4	5	6	7	8	9	10	11	12	13	14	3	-	L
150	0.07	100	0.05	Δ_{10}	3	$_{P}4^{\pi}$	$_{P}5^{\pi}$	6	7	8	9	10	11	12	13	5	-	K
			0.07	Δ_{9}	2	3	4	5	6	7	8	9	10	11	11	7	-	J
55	0.15	45	0.11	Δ_{8}	$_{P}1^{\pi}$	2	3	4	5	6	7	8	9	10	10	11	6	I
			0.16	Δ_{7}	0	1	2	3	4	5	6	7	8	9	9	16	17	H
20	0.34	20	0.24	Δ_{6}	0	$_{P}0^{\pi}$	$_{P}1^{\pi}$	2	3	4	5	6	7	8	8	24	30	G
			0.36	Δ_{5}	0	0	0	1	2	3	4	5	6	6	7	36	42	F
7	0.77	9	0.55	Δ_{4}	0	$_{P}0^{\pi}$	0	0	1	2	3	4	4	5	6	55	55	E
			0.77	Δ_{3}	0	$_{P}0^{\pi}$	$^{P}0_{\pi}$	0	0	1	2	3	4	4	5	77	66	D
3	1.53	4	1.09	Δ_{2}	0	$_{P}0^{\pi}$	0	0	0	0	1	2	3	4	5	109	77	C
			1.69	Δ_{1}	0	0	0	0	0	0	0	1	2	2	3	169	90	B
1	3.68	2	2.63		$^{P}0_{\pi}$	$^{P}0_{\pi}$	$^{P}0_{\pi}$	0	0	0	0	0	0	1	2	263	104	A
						Δ_{1}	Δ_{2}	Δ_{3}	Δ_{4}	Δ_{5}	Δ_{6}	Δ_{7}	Δ_{8}	Δ_{9}	Δ_{10}			
					1	3	7	1	2	6	2	7	4	11	30			
					Hours			Days			Weeks		Months					
					a	b	c	d	e	f	g	h	i	j	k			

Figure 1. Impact Assessment Model for Clear Water Fishes Exposed to Conditions of Reduced Water Clarity. A model to estimate severity of impact on rearing success of clear water fish as a function of reduced visual clarity of water (m) and duration of exposure (h), for juvenile and adult life history phases; includes calibration for reactive distance of trout.

KEY:

- yBD — Black disk sighting range (m): horizontal measurement in water of any depth (reciprocal of beam attenuation).
- ψBD — Black disk sighting range (cm): a convenient calibration for measurements made in very cloudy water.
- BA — Beam attenuation (m^{-1}): measures absorption and scattering of light by "water constituents" – clay and color; reciprocal of black disk sighting range.
- zSD — Secchi disk sighting range (m): a vertical measurement, usually in deep water.
- xRD — Reactive distance of adult trout (pooled data for rainbow, lake and brook) to fish prey as a function of visual clarity. Alternate, proportional, calibrations can be inferred for largemouth bass and bluegill based on their maximum reaction distances (200 cm, and 30 cm, respectively).
- NTU — Nephelometric turbidity units: a measure of light scattering by suspended clay particles (0.2 to 5 μm diameter).
- SEV — Severity of Ill Effect Scale
  - a. Semi-Quantitative
    $0 \leq$ nil < 0.5; $0.5 \leq$ minor < 3.5; $3.5 \leq$ moderate < 8.5; $8.5 \leq$ severe < 14.5. Impact assessment is based on net duration (less clear water intervals) and weighted average visual clarity data. Recurrent events sum when integrated over relevant intervals: for a year class (a life history phase, or a life cycle); a population ("year over year" events); habitat damage (hours < duration ≤ years); and restoration (year < time ≤ years). For events involving suspended sediment (may include clay as one of the particle sizes in a range of sizes) (see Newcombe and Jensen, 1996).
  - b. Qualitative
    - 0: *Ideal*. Best for adult fishes that must live in a clear water environment most of the time.
    - 1-3: *Slightly Impaired*. Feeding and other behaviors begin to change.
    - 4-8: *Significantly Impaired*. Marked increase in water cloudiness could reduce fish growth rate, habitat size, or both.
    - 9-14: *Severely Impaired*. Profound increases in water cloudiness could cause poor "condition" or habitat alienation.
  - c. Stipple – Areas with least available data (1 day to 30 months).

Predator Prey Dynamics

- (a) $^{P}0_{\pi}$: Some predatory fish (P) catch more prey fish (π) in clear water ($^{P}\pi$) than they do in cloudy water.
- (b) $p1^{\pi}$, $p5^{\pi}$: Survival of some fishes is enhanced (p^{π}) by natural, seasonal, cloudiness (two examples shown).
- (c) *SEV*: Severity of ill effect data, underscored, are from published sources (see Literature Cited), or have the support of consensus within the discussion group, or both.

aA, kO — Row labels (upper case) and column labels (lower case); paired, these serve as cell coordinates (two examples shown).

Figure 5. Impact Assessment Model for Clear Water Fishes Exposed to Conditions of Reduced Water Clarity (from Newcombe 2003).

Ratings:

Risks to each life stage were assessed according to the seasonality of effects produced by the turbidity for each life stage across all IP-km. Ratings were based upon the percentage of IP-km habitat within a population maintaining a moderate or lower sub lethal effect in regard to turbidity dose (*i.e.*, based upon both concentration and exposure duration). The extent that favorable turbidity conditions exist across the spatial population scale determined the overall score for a given population.

Data regarding turbidity was unavailable for many populations. In the absence of turbidity data, information and data from reports regarding sediment input from roads, sediment contributions from landslides and other anthropogenic sources, and best professional judgment was used to assess turbidity risk at the population scale.

Rating criteria were as follows:

Poor = < 50% of IP-km maintains score of 3 SEV or lower;
Fair = 50% to 74% of IP-km maintains score of 3 SEV or lower;
Good = 75% to 90% of IP-km maintains score of 3 SEV or lower; and
Very Good = > 90% of IP-km maintains score of 3 SEV or lower.

Stress:
The stress associated with this indicator is Water Quality: Turbidity or Toxicity. This was compared against all threats except Fishing/Collecting which does not affect the indicator.

3. <u>Toxicity</u>
Steelhead: Adults, Summer Rearing, Winter Rearing, Smolts, Summer Adults
Chinook: Adults, Pre Smolt, Smolts

Optimal conditions for salmonids, their habitat and prey, include clean water free of toxins, contaminants, excessive suspended sediments, or deleterious temperatures. Toxins are substances (typically, but not always, anthropogenic in origin) which may cause acute, sub-lethal, or chronic effects to salmonids or their habitat. These include (but are not limited to) toxins known to impair watersheds, such as copper, nutrients, mercury, polyaromatic hydrocarbons (PAHs), pathogens, pesticides, and polychlorinated biphenyls (PCBs), herbicides and algae.

All target life stages of salmonids depend on good water quality, and the water quality attribute is impaired when toxins or other contaminants are present at levels adversely affecting one or more salmonid life stage, their habitat or prey. Salmonids are sensitive to toxic impairments, even at very low levels (Sandahl *et al.* 2004; Baldwin and Scholz 2005). For example, adult salmonids use olfactory cues to return to their natal streams to spawn, and low levels of copper has been show to impair this ability (Baldwin and Scholz 2005).

Adult salmon typically begin their freshwater migration from the ocean to their natal streams after heavy late-fall or winter rains breach the sand bars at the mouths of coastal streams (Sandercock 1991). These same flows may carry toxins from a variety of point and non-point sources to the stream. The exposure of returning adults to toxins in portions of their IP-km can reduce the viability of the population by impairing migratory cues, or reducing the amount of available spawning and rearing habitat, thereby lowering the carrying capacity of the population. Each life stage was assessed according to the seasonality of effects produced by the toxin across all IP-km.

Methods:
For this analysis, some constituents were excluded from consideration because they were assessed by other indicators (*i.e.,* Water Quality/Temperature). We reviewed a variety of materials to derive appropriate ratings, including data from the various Regional Water Quality Control Boards, the U.S. Environmental Protection Agency, and other local and regional sources to inform our ratings of water quality for any toxins known or suspected of causing impairment to fish. We also reviewed scientific literature, and available population-specific water quality reports. Working with SEC and NMFS water quality specialists, a qualitative decision structure was developed (Figure 6) to rate each population where more specific data were lacking.

Decision Matrix for Each Life Stages/Water Quality/Toxicity for Key Independent/Dependent Populations

Each life stage must be assessed according to the seasonality of effects produced by the toxin across all IP-km.

1. Are toxins/chemicals present in the watershed which could potentially (through direct discharge, incidental spills, chronic input, *etc.*) enter the water column?

    a. Yes: go to number 2
    b. No: Toxicity not a threat (assumed to be Good)

2. Is the chemical/substance a known toxin to salmonids?

    a. Yes: go to number 3
    b. No: Toxicity not a threat (assumed to be Good)

3. Are salmonids spatially/temporally exposed to the toxin during any life stage or are the toxins present in a key subwatershed (where salmonids no longer occur) important for species viability?

    a. Yes: go to number 4
    b. No: Toxicity not a threat (assumed to be Good/Fair)

4. Potential salmonid presence to toxin established. Use best professional judgment to assign Fair/Poor rating. Consider toxicity of chemical compound, persistence of the compound, spatial extent/temporal exposure, future reintroduction efforts, and potential overlap of land use activities (*e.g.*, pesticide/herbicide intensive farming practices) to species viability/presence when assigning rating.

Figure 6. Qualitative decision structure for evaluating water quality/toxicity. The matrix was used to determine the likelihood of toxins being present and adversely affecting freshwater salmonid life history stages.

Ratings:

Ratings for evaluating the risk of adverse effects to salmonids due to toxicity are:

> Poor = Acute effects to fish and their habitat (*e.g.*, mortality, injury, exclusion, mortality of prey items);
>
> Fair = Sub lethal or chronic effects to fish and their habitat (*e.g.*, limited growth, periodic exclusion, contaminants elevated to levels where they may have chronic effects). Chronic effects could include suppression of olfactory abilities (affecting predator avoidance, homing, synchronization of mating cues, *etc.*), tumor development (*e.g.*, PAHs). This could include populations without data but

where land use is known to contribute pollutants (*e.g.*, significantly urbanized or supporting intensive agriculture, particularly row crops, orchards, or confined animal production facilities);

Good = No acute or chronic effects from toxins are noted and/or population has little suspect land uses, and insufficient monitoring data are available to make a clear determination. Many Northern California populations (particularly those held in private timber lands) are likely to meet these criteria; and

Very Good = No evidence of toxins or contaminants. Sufficient monitoring conducted to make this determination, or areas without contributing suspect land uses (*e.g.,* many wild and scenic rivers, wilderness areas, *etc*.). Available data should support very good ratings.

Stress:
The stress associated with this indicator is Water Quality: Turbidity or Toxicity. This was compared against all threats except Fishing/Collecting which does not affect the indicator.

1.5 ASSESSING FUTURE CONDITIONS: SOURCES OF STRESS (THREATS)

The CAP protocol defines threats as the source of the identified stress likely to continue into the future. Threats to salmonids are driven by human activities and naturally occurring events. For each population and life stage, threats were rated using two metrics, contribution and irreversibility. These are combined by CAP algorithms to generate a single rating for each threat identified.

1. Contribution is the expected contribution of the threat, acting alone, on the stress under current circumstances (*i.e.*, given the continuation of the existing management). Threats rated as Very High for contribution are very large contributors to the particular stress and Low ratings are applied to threats that contribute little to the particular stress. Contribution is rated from Very High to Low according to the following criteria:
    - Very High: The threat is a dominant contributor acting on the stress;
    - High: The threat is a significant contributor acting on the stress;
    - Medium: The threat is a moderate contributor acting on the stress;
    - Low: The threat is a low contributor acting on the stress.
2. Irreversibility is defined as the degree to which the effects of a threat can be reversed. Irreversibility is rated from Very High to Low according to the following criteria:

- Very High: Generally not reversible;
- High: Moderately reversible with a significant commitment of resources;
- Medium: Reversible with a reasonable commitment of resources;
- Low: Easily reversible and at a low cost.

Threats with a high level of contribution to a stress and/or high irreversibility are rated as High or Very High. The list of threats is based on their known impact to salmonid habitat, species viability, and the likelihood that the threat would continue into the future. For example, in Table 18, the threat of residential and commercial development was rated as very high for summer juveniles and high for adults, winter rearing and smolts due to poor water quality and impaired riparian conditions in San Lorenzo River. Threats rated as High or Very High are more likely to contribute to a stress that, in turn, reduces the viability of a target life stage. When multiple life stages of a population have High or Very High threats, the viability of the population is diminished.

Table 18. Example of a summary threat table.

Summary of Threats

Central California Coast Steelhead ~ San Lorenzo River

	Threats Across Targets	Adults	Eggs	Summer Rearing Juveniles	Winter Rearing Juveniles	Smolts	Watershed Processes	Overall Threat Rank
	Project-specific threats	1	2	3	4	5	6	
1	Roads and Railroads	High	High	Very High	Very High	High	Very High	Very High
2	Severe Weather Patterns	Medium	High	Very High	High	High	Very High	Very High
3	Water Diversion and Impoundments	Medium	Medium	Very High	Medium	High	Very High	Very High
4	Residential and Commercial Development	High	Medium	Very High	High	High	High	Very High
5	Channel Modification	Medium	Medium	Very High	High	High	Medium	High
6	Recreational Areas and Activities	Medium	Low	Very High	Medium	High	Medium	High
7	Fire, Fuel Management and Fire Suppression	Medium	Medium	High	High	Medium	Medium	High
8	Logging and Wood Harvesting	Medium	Medium	Medium	High	Medium	Medium	High
9	Disease, Predation and Competition	Medium	Low	Medium	Medium	High	Medium	Medium
10	Agriculture	Medium	Medium	Medium	Medium	Low	Medium	Medium
11	Mining	Medium	Medium	Medium	Medium	Low	Medium	Medium
12	Livestock Farming and Ranching	Low	Low	Medium	Medium	Low	Medium	Medium
13	Fishing and Collecting	Medium	-	Low	-	Medium	-	Medium
14	Hatcheries and Aquaculture	Low	-	Low	Low	Medium	-	Low
	Threat Status for Targets and Project	High	High	Very High	Very High	Very High	Very High	Very High

Very High or High threats are driven by social, economic, or political causes that then become the focus of conservation strategies. Conservation strategies are developed into recovery actions intended to reduce or abate High or Very High threats. In some cases recovery actions were developed for Medium threats based on knowledge or information that the threat could increase in the near future due to anticipated changes. The following section describes each threat and the information considered for rating each major threat to salmonid recovery.

Some threats (*e.g.*, roads) occurred in all or most populations, while others (*e.g.*, mining) were more limited in distribution. Where a threat did not occur in a given population, it was not evaluated and did not receive a rating. In addition, some threats affected all life stages, such as Residential and Commercial Development. Others affected only a few life stages, such as Fishing/Collecting.

As with CAP, for the rapid assessments, algorithms combined the stress/threat scores to generate a total overall score for each threat. Threats were scored from Low to High (Table 19).

Table 19. Example of a rapid assessment threat table for CCC and NC steelhead.

NC Steelhead DPS: Central Coastal Diversity Stratum (Brush/Elk/Schooner Gulch)													
Threat Scores **L: Low** **M: Medium** **H: High**		**Stresses**											
		Altered Riparian Species: Composition & Structure	Estuary: Impaired Quality & Extent	Floodplain Connectivity: Impaired Quality & Extent	Hydrology: Gravel Scouring Events	Hydrology: Impaired Water Flow	Impaired Passage & Migration	Instream Habitat Complexity: Altered Pool Complexity and/or Pool/Riffle Ratio	Instream Habitat Complexity: Reduced Large Wood and/or Shelter	Instream Substrate/Food Productivity: Impaired Gravel Quality & Quantity	Reduced Density, Abundance & Diversity	Water Quality: Impaired Instream Temperatures	Water Quality: Increased Turbidity or Toxicity
Threats - Sources of Stress	Agriculture	L	L	L	L		L	L	M	M		L	L
	Channel Modification	L	L	L	L	L	L	L	M	L		L	L
	Disease, Predation, and Competition	L	L	L			L	L	M		L	L	L
	Fire, Fuel Management, and Fire Suppression	L	L	L	L		L	L	H	M		L	M
	Livestock Farming and Ranching	L	L	L	L		L	L	L	L		L	L
	Logging and Wood Harvesting	L	L	L	L		L	M	H	M		L	M
	Mining	L	L	L	L		L	L	L	L		L	L
	Recreational Areas and Activities	L	L	L	L		L	L	M	L		L	L
	Residential and Commercial Development	L	L	L	L		L	L	M	L		L	L
	Roads and Railroads	L	L	L	L		L	L	M	M		L	M
	Severe Weather Patterns	L	L	L	L	M	L	L	M	M		L	M
	Water Diversions and Impoundments	L	H	L	L	M	L	M	M	M	M	L	L
	Fishing and Collecting										H		
	Hatcheries and Aquaculture										L	L	L

To reduce overestimating impacts of a stress across multiple threats, NMFS developed a matrix illustrating which threats contribute to a particular stress (Table 20). This ensured a direct linkage between the threat and a particular stress. For example, the threat of fishing and collecting was only rated against the population stress of reduced abundance, diversity, and competition, and did not affect the egg life stage. This approach reduced the potential for over estimating the effect of a stress across multiple threats. Finally, the matrix facilitated the development of recovery actions with direct relationships to stresses or threats.

Table 20. Matrix showing which threats were evaluated against which stresses.

Stresses	Habitat Condition											Watershed Processes			Population
Threats	Estuary: Impaired Quality & Extent	Floodplain Connectivity: Impaired Quality & Exent	Hydrology: Gravel Scouring Events	Hydrology: Impaired Water Flow	Instream Habitat Complexity: Altered Pool	Instream Habitat Complexity: Reduced Large Wood	Instream Substrate/ Food Productivity: Impaired	Impaired Passage & Migration	Water Quality: Increased Turbidity or Toxicity	Water Quality: Impaired Instream Temperatures	Altered Riparian Species Composition & Structure	Impaired Watershed Hydrology	Landscape Distrubance	Altered Sediment Transport: Road Construction	Reduced Density, Abudance & Diversity
Agriculture				N/A											N/A
Channel Modification															N/A
Disease/Predation/ Competition(Invasive Animals and Plants)			N/A	N/A			N/A								
Fire				N/A											N/A
Fishing/Collecting	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Hatcheries	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A			N/A	N/A	N/A	N/A	
Livestock				N/A											N/A
Logging				N/A											N/A
Mining				N/A											N/A
Recreation				N/A											N/A
Residential Development				N/A											N/A
Roads				N/A											N/A
Severe Weather Patterns															N/A
Water Diversion and Impoundments															

1.5.1 AGRICULTURE

Agriculture is annual and perennial crop farming and associated operations (excludes grazing, ranching or timber harvest). Agricultural practices can adversely affect salmonid habitats by (1) altering riparian species composition and buffer widths, (2) altering natural drainage patterns, and (3) introducing water-borne pollutants (*i.e.,* fine sediment, herbicides, and pesticides).

The major agricultural crops grown within the NCCC Domain are vineyards, orchards (apples, pears, *etc*.) and marijuana, generally located north of the Golden Gate. Brussels sprouts, lettuce, and flower crops (greenhouse and row crops) are found in the southern coastal areas of the Domain.

Some agricultural activities and programs have made efforts to improve riparian protections, implementing pollution and sediment discharge controls, and promoting instream habitat restoration (*e.g.,* Fish Friendly Farming, TMDL's and others). However, the overall adverse impact to salmonids and their habitat is generally very significant where these activities occur, and particular aspects of agriculture can have major direct and indirect impacts (*e.g.,* use of pesticide to control insects and weeds, agricultural runoff containing pesticides, nutrients or sediments, and removal of riparian vegetation from farming areas due to food safety requirements regarding *E. coli*).

Methods:
The analysis included the threats of agricultural practices and all associated operations of developing and maintaining continuous or seasonal ground disturbance, planting, harvesting, fertilizing, and irrigating row crops, orchards, vineyards, legal and illegal marijuana plantations, commercial greenhouses, nurseries, gardens, *etc.* Threats were evaluated for their potential to:

1. Introduce into the stream channel water-borne pollutants such as pesticides or elevate nutrient levels;
2. Alter riparian vegetation integrity, diversity, function, and composition;
3. Alter drainage channels and hydrology patterns; and
4. Simplify channel complexity and destabilize stream banks.

NMFS analysts used GIS analysis of the percentage of land zoned for agriculture, watershed specific assessments, staff knowledge of watersheds and ongoing practices, and best professional judgment to determine ratings.

Ratings:
The final threat ratings were determined by the following criteria:

High or Very High threat = Ecosystem function and process are (or are expected to be) severely altered. High or very high threats could include practices requiring large areas in cultivation and large quantities of pesticides and herbicides over significant proportions of the watershed.

Medium threat = Ecosystem function and process are (or are expected to be) moderately altered, but the effects could be reversed or ameliorated.

Low threat = Ecosystem function and process are (or are expected to be) largely intact, slightly altered, and easily reversible. A low threat could include practices that have a low impact and use little or no herbicides and pesticides in the watershed and do not impact riparian vegetation.

1.5.2 Channel Modification

Channel modification directly and/or indirectly modifies and/or degrades natural channel-forming processes and morphology of perennial, intermittent and ephemeral streams and estuarine habitats. Channel modifying structures such as levees, flood control channels, and bank hardening (riprap and gabions) reduce the occurrence and creation of undercut banks and side channels, limit or eliminate important habitat forming features, and often result in the removal of riparian vegetation. These techniques are used extensively to modify stream banks and beds. Channel modifications eliminate or severely reduce streambed gravel recruitment and retention necessary for salmonid spawning and food production. Bank stabilization, levee construction for flood control, and filling in of off channel areas for land reclamation, disconnect rivers and streams from their floodplains. These activities modify and/or prevent the creation of, or block access to, refugia habitats used by salmonids for feeding and as refuge during high stream flows. Overall, channel modification can severely affect stream geomorphic processes.

In an effort to protect public and private infrastructure and property (roads, bridges, homes and commercial buildings) located in flood prone zones and adjacent to streams, channel modification has reduced salmonid habitat suitability by permanently altering natural channel forming processes. The impact of channel modification is a major constraint to salmonid viability in many of the heavily urbanized watersheds within the NCCC Domain.

Currently, in most circumstances, permits from the U.S. Army Corps of Engineers are required for channel modifications, which in turn require ESA consultations with NMFS. However, the majority of habitat damage resulting from channel modification (including channelization, removal of LWD, and placement of rock slope protection, *etc.*) occurred prior to the listing of Chinook salmon and steelhead. Nonetheless, most current channel modifying practices usually occur over a relatively small area and the cumulative impacts are difficult to evaluate and are infrequently addressed by regulatory agencies. Once channel modifying infrastructure is in place it is usually followed by increased development, which in turn leads to additional channel modification. When infrastructure is in place (on the floodplain and/or adjacent to a stream) it is often impractical, difficult, and expensive to remove. With a growing human population the pressure to modify natural stream channels is anticipated to continue.

Methods:
The analysis included evaluation of estuarine management (*e.g.*, lagoon breaching, dredging), flood control activities, large woody debris removal, levee construction and maintenance, vegetation removal, herbicide application, stream channelization, bank stabilization (hardening that limits channel movement or meander), dredging and other forms of sediment removal. These actions typically occur within the two-year bankfull stage and adversely affect salmonid habitat.

Threats were evaluated for their potential to:

1. Damage instream and near stream habitat and lower habitat complexity;
2. Precipitate riparian habitat loss, decreasing channel roughness (decrease in Manning's N roughness coefficient);
3. Alter drainage channels and hydrologic patterns;
4. Alter riparian zone diversity, function, and composition;
5. Alter stream bank stability;
6. Alter or destroy floodplain/estuarine/wetland habitats;
7. Introduce water-borne pollutants into the aquatic environment, and/or adversely alter nutrient levels; and
8. Simplify channel morphology (*e.g.*, incision rate and floodplain connectivity).

Ratings:
No central repository of channel modifying activities exists for watercourses in the NCCC Domain, and the quality and quantity of information varies significantly between watersheds. Information sources included watershed assessments, CDFW habitat typing information, personal communications with local experts, and staff knowledge of individual watersheds. The final threat ratings were determined by the following criteria:

High or Very High = Ecosystem function and process are (or are expected to be) severely altered. High or very high threats could include large levee projects within salmonid habitat that adversely modify sediment transport, impair salmonid migration, accelerate stream velocities, and alter riparian vegetation structure from historical conditions.

Medium = Ecosystem function and process are (or are expected to be) moderately altered but could be reversed or ameliorated.

Low = Ecosystem function and process are (or are expected to be) largely intact, slightly altered, and easily reversible. A lower threat could include bank stabilization projects that use bioengineering techniques.

1.5.3 Disease, Predation and Competition

Diseases and native (*e.g.*, sea lions, mergansers, *etc.*) and non-native species (*e.g.*, *Arundo donax*, Quagga mussel, largemouth bass, striped bass, and pikeminnow) may have significant harmful effects on salmonids and/or their habitat. Infectious disease can influence adult and juvenile salmonid survival. Salmonids are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environment. Specific diseases such as bacterial kidney disease, *Ceratomyxosis, Columnaris, Furunculosis*, infectious hematopoietic necrosis virus, redmouth and black spot disease, erythrocytic inclusion body syndrome, and whirling disease, among others, are known to affect salmonids (Rucker *et al.* 1953; Wood 1979; Leek 1987; Foott *et al.* 1994).

Cooper and Johnson (1992) and Botkin *et al*., (1995) reported marine mammal and avian predation may occur on some local salmonid populations, but it was a minor factor in the decline of coast-wide salmonid populations. According to Moyle (2002), predation by seals and sea lions on returning fish, when populations are low, may prevent recovery.

Principal competitors for the food and space of juvenile salmonids are other salmonids (Moyle 2002). Osterback *et al.* (2013) documented avian predation as a major potential constraint to steelhead juveniles and smolts in Scott Creek. Other sources of competition include alien species, including alien riparian species (such as *A. donax*) which can completely disrupt riparian communities and instream processes.

Disease, predation and competition may significantly influence salmonid abundance in some local populations when other prey species are absent and physical conditions lead to the concentration of salmonid adults and juveniles (Cooper and Johnson 1992). Also, altered stream flows can create unnatural riverine conditions that favor the non-native species life histories more than the native cold water species (Brown *et al.* 1994; CDFG 1994; McEwan and Jackson 1996; NMFS 1996b).

Methods:

Relative to the other threats, disease and predation are likely not major factors contributing to the overall decline of salmonids in the NCCC Domain. However, they may compromise the ability of depressed populations to rebound. Competition in the context of habitat alteration leading to reduced survival is a serious limiting factor for some salmonid populations.

NMFS analysts considered the following factors: (1) introduction of non-native animal species that prey upon and/or (directly or indirectly) compete with native salmonids; (2) introduction of non-native vegetation that competes with and/or replaces native vegetation; and (3) creation of conditions favorable to increased populations and/or concentration of native predators. Threats were evaluated for their potential to:

1. Simplify or modify instream or riparian habitat condition;
2. Reduce feeding opportunities (*e.g.*, Quagga mussel);
3. Shift the natural balance between native/non-native biotic communities and salmonid abundance, resulting in disproportionate impacts from predation and competition;
4. Increase opportunities for infectious disease;
5. Change water chemistry (*e.g.*, inputs of acidic detritus from eucalyptus, or low DO resulting from increased foreign biomass); and,
6. Impede instream movement and migration, or reduce riparian function (*e.g.*, *A. donax*).

Ratings:
NMFS used a variety of resources to evaluate this threat, from region-wide assessments of the impacts of predation to site specific watershed assessments and individual reports. In general, there was little site specific information to evaluate this threat, and in many cases staff used best professional judgment and solicited the opinions of local experts. The final threat ratings were determined by the following criteria:

High or Very High = Ecosystem function and process are (or are expected to be) severely altered, or impacts to the population are severe. High or very high threats occur when amelioration of the consequences of this threat are largely irreversible.

Medium = Ecosystem function and process are (or are expected to be) moderately altered, but the effects could be reversed or ameliorated, or impacts to the population are moderate. Medium threats occur when the consequences of this threat are largely irreversible but could be ameliorated.

Low = Ecosystem function and process are (or are expected to be) largely intact, slightly altered, and easily reversible.

1.5.4 Fire and Fuel Management

Fire, from prescriptive burns to catastrophic wildfires, can impair salmonid habitat by reducing or eliminating stream side canopy and triggering increased soil erosion through mass wasting events or chronic sediment input that can render instream rearing habitat unsuitable for many decades. Hotter fires consume organic matter that binds soils, leading to an increase in erosion potential; in the worst case, high intensity fires can volatilize minerals in the soil causing it to become hydrophobic. Spence *et al*., (1996) recognized the extent of watershed damage and risk to salmonid habitat is directly related to burn intensity.

Wildland fires are a common occurrence in the NCCC Domain and many of the watersheds are heavily vegetated and prone to burning. Some areas are very susceptible to catastrophic wildfire due to decades of fire suppression that have increased fuel loads beyond historical conditions. The interior and southern areas of the NCCC Domain may have significant fire risk with potential for watershed disturbance and increased sediment yield. Coastal and northern areas have higher rainfall, more resilient vegetation (redwood forest), less extreme summer air temperatures and, therefore, less risk of catastrophic fire.

Fire management and firefighting impacts to listed salmonids are expected to be inadvertent but, in certain situations, could further impair watershed conditions. Few areas in the southern part of the NCCC Domain are on federal lands, so most firefighting activities are conducted by local fire districts and CalFire. Unlike federal lands, where NMFS has extensive interaction with the Forest Service and Bureau of Land Management to minimize adverse consequences from firefighting actions, NMFS has little interaction with firefighting agencies in the southern portion of the NCCC Domain. Consequently, impacts from firefighting (road building, water diversion, aerial retardants) likely have a greater adverse impact to salmonids and their habitats than in northern areas.

Methods:
Susceptibility of an area to wildfire, construction of fire breaks and roads, application of fire retardants, water use planning, fuels management, and fire suppression were all considered in the analysis of fire and fuel management as a threat to Chinook salmon and steelhead. Threats were evaluated for their potential to:

1. Increase erosion, sedimentation and landslide potential;
2. Elevate fuel loading leading to a higher potential of catastrophic burns;
3. Impair future large woody debris recruitment, and;
4. Alter vegetative/riparian communities through invasive species/post-fire management.

Ratings:
Current prediction for regional effects from fire intensity, frequency and duration as well as fire and fuel management practices (fire suppression, prescribed burning and limited use of mechanical treatments to reduce fire fuel loads) were examined. NMFS

used a variety of resources to evaluate this threat, from region-wide CalFire assessments of fire risk, to site specific watershed assessments and individual reports. In general, there was little site specific information to evaluate this threat, and in many cases staff used best professional judgment and solicited the opinions of local experts. The final threat ratings were determined by the following criteria:

High or Very High = Ecosystem function and process are (or are expected to be) severely altered. High or Very High threats may include high fuel loading over a large area, or extensive burns upstream of, or adjacent to, critical spawning and rearing areas.

Medium = Ecosystem function and process are (or are expected to be) moderately altered, but the effects could be reversed or ameliorated.

Low = Ecosystem function and process are (or are expected to be) largely intact, slightly altered, and easily reversible. A mature redwood forest upstream or adjacent to salmonid habitat generally will rate as a Low threat due to the fire resistant qualities of redwood.

1.5.5 FISHING AND COLLECTING

Fishing and collecting salmonids for recreation, commercial, subsistence, in-situ research, or cultural purposes were all considered in the CAP analysis. This threat also includes illegal and legal activities such as accidental mortality/bycatch.

Commercial fishing for Chinook salmon is managed under the Magnuson-Stevens Fishery Conservation and Management Act. Sport fishing for steelhead and Chinook salmon is governed by CDFW regulations. Steelhead fishing is limited to hatchery stocks with clipped adipose fins. All wild steelhead must be released unharmed. However, threatened salmon and steelhead are incidentally caught as bycatch by both commercial and sport fisheries. These activities are most likely to impact the adult lifestage. The specific amount of bycatch is unknown, but it may have a significant adverse effect due to the extremely low population levels where every individual is of greater significance to the population's persistence than when the population levels were large. Fish mortality caused by activities such as fishing could be more damaging to the population when populations are depleted due to natural conditions (such as changes in ocean productivity) (NRC 1996). Handling hooked fish before releasing them also contributes to mortality (Clark and Gibbons 1991). According to Moyle (2002), present populations are so low that moderate fishing pressure on wild salmonids may slow or prevent recovery, even in places where stream habitats are adequate.

The bag limits set forth in the 2014-2015 California Freshwater Sport Fishing Regulations (Table 21) are likely a source of confusion for some fishers and should be amended to reflect actual fishery conditions. Several watersheds have a bag limit for both hatchery trout or hatchery steelhead, when in reality only the Mad River, Russian River, Scott Creek, and the San Lorenzo River have hatchery trout or steelhead plantings. The current stated bag limits may encourage fishers to unknowingly target specific streams where no stocking occurs and, in turn, incidentally hook listed salmonids. Many streams also have minimum flow requirements that trigger closure of fishing at low flows. The application of stream flow requirements, however, is problematic from an enforcement standpoint, as individuals may not have access to such information.

In addition to bag limits, CDFW has instituted some area closures to protect salmonids at the mouths of major rivers, including the Smith, Klamath and Eel Rivers (Title 14, California Code of Regulations, § 27.75.

Table 21. Selected watersheds where winter freshwater fishing for hatchery steelhead is permitted by California 2014-2015 sport-fishing regulations. Only the Mad River, Russian River, Scott Creek, and the San Lorenzo River have hatchery releases. Note: sport-fishing regulations include additional possession limits and additional regulations may apply.

Watershed	Season	Daily Bag Limit
Albion River	4th Saturday in May - Mar 31	2 hatchery trout or hatchery steelhead
Aptos Creek	Dec 1 - Mar 7	2 hatchery trout or hatchery steelhead
Bear River	4th Saturday in May - Mar 31	2 hatchery trout or hatchery steelhead
Big River	4th Saturday in May - Mar 31	2 hatchery trout or hatchery steelhead
Brush Creek	4th Saturday in May - Mar 31	2 hatchery trout or hatchery steelhead
Cottaneva Creek	4th Saturday in May - Mar 31	2 hatchery trout or hatchery steelhead
Coyote Creek	Last Saturday in April - Nov 15	2 hatchery trout or hatchery steelhead
Eel River (mainstem)	Varies by reach	2 hatchery trout or hatchery steelhead
Elk Creek	4th Saturday in May - Mar 31	2 hatchery trout or hatchery steelhead
Garcia River	4th Saturday in May - Mar 31	2 hatchery trout or hatchery steelhead
Guadalupe River	Last Saturday in April - Nov 15	2 hatchery trout or hatchery steelhead
Gualala River	4th Saturday in May - Mar 31	2 hatchery trout or hatchery steelhead
Humboldt Bay tributaries	4th Saturday in May - Oct 31	2 hatchery trout or hatchery steelhead
Lagunitas Creek	Closed	Zero
Little River	4th Saturday in May - Mar 31	2 hatchery trout or hatchery steelhead
Mad River	Varies by reach	2 hatchery trout or hatchery steelhead
Mattole River	Varies by reach	2 hatchery trout or hatchery steelhead
Middle Fork Eel River	Varies by reach	2 hatchery trout or hatchery steelhead
Napa River	Varies by reach	2 hatchery trout or hatchery steelhead
Navarro River	4th Saturday in May - Mar 31	2 hatchery trout or hatchery steelhead
Noyo River	4th Saturday in May - Mar 31	2 hatchery trout or hatchery steelhead

Pescadero Creek	Dec 1 - Mar 7	2 hatchery trout or hatchery steelhead
Redwood Creek (Humboldt Co.)	Varies by reach	2 hatchery trout or hatchery steelhead
Russian River	Varies by reach	2 hatchery trout or hatchery steelhead
Salmon Creek	Varies by reach	2 hatchery trout or hatchery steelhead
San Francisquito Creek	Closed	Zero
San Gregorio Creek	Dec 1 - Mar 7	2 hatchery trout or hatchery steelhead
San Lorenzo River	Dec 1 - Mar 7	2 hatchery trout or hatchery steelhead
Scott Creek	Dec 1 - Mar 7	Zero
Soquel Creek	Dec 1 - Mar 7	2 hatchery trout or hatchery steelhead
Ten Mile River	4th Saturday in May - Mar 31	2 hatchery trout or hatchery steelhead
Van Duzen River	Varies by reach	2 hatchery trout or hatchery steelhead
Waddell Creek	Dec 1 - Mar 7	2 hatchery trout or hatchery steelhead
Walker Creek	4th Saturday in May - Mar 31	2 hatchery trout or hatchery steelhead

Commercial and ocean sport-fishing near the mouths of a watershed when sandbars remain closed may inadvertently result in increased rates of adult capture. Adult salmonids congregating offshore while awaiting entry into the estuaries are likely at more risk of capture than those returning to watersheds without sandbars, or where sandbars have naturally breached.

Methods:
To evaluate this threat, NMFS analysts considered incidental harvest for recreation and subsistence, authorized relocation, research and collection, incidental capture (*e.g.*, hooking), and illegal activities such as poaching and unpermitted collection.

Threats were evaluated for their potential to:

1. Increase mortality/harm and displacement;
2. Increase competition when fish are relocated; and
3. Precipitate depensatory effects at the population level.

Ratings:
Recreational steelhead angling was the principle activity considered for this indicator rating because it is the type of fishing most likely to impact adult salmonids. We rated the impact of Fishing and Collecting by tallying the number of fishing trips reported in the CDFW Steelhead Report Card during each species' adult migration period for the most recent year of record. The final threat ratings were determined by the following criteria:

High or Very High = Impacts to the population are (or are expected to be) severe. High or Very High threats may occur in critical adult staging areas with extensive legal and illegal fishing pressure.

Medium = Impacts to the population are (or are expected to be) moderate but could be reversed or ameliorated.

Low = Impacts to the population are (or are expected to be) low and easily reversible. Low threats may occur in watersheds under large private (i.e., commercial timberlands) ownership where public access is restricted or in areas with significant enforcement presence.

1.5.6 HATCHERIES AND AQUACULTURE

Hatcheries are artificial propagation facilities designed to produce fish for harvest. A conservation hatchery differs from a production hatchery since it specifically tries to supplement or restore naturally spawning salmon populations. Artificial propagation, especially the use of production hatcheries, has been a prominent feature of Pacific salmon fisheries enhancement efforts for several decades. Historically, out of basin and out-of-ESU/DPS hatchery salmonids were released in many watersheds in the ESU/DPSs. Potential impacts to salmonids from hatchery operations include a number of categories including genetic, ecological, overfishing, behavioral, and disease.

The following was adopted from Appendix C, in Spence *et al*. (2008), which provides guidance on evaluating hatchery risks on salmonid populations.

Genetic Risks

Genes determine the characteristics of living things. Human intervention in the rearing of wild animals has the potential to cause genetic change. These genetic changes impact salmon diversity and the health of salmon populations. Hatchery programs vary and therefore the risks identified below vary by hatchery. Genetic risks of artificial propagation on wild populations include:

1) Inbreeding

Inbreeding can occur when the population for a hatchery comes from a small percentage of the total wild and/or hatchery fish stock (for example, 100 adults are used out of a population of 1 million). If only a small number of individuals are used to create the new hatchery stock, genetic diversity within a population can be reduced. Inbreeding can affect the survival, growth and reproduction of salmon.

2) Intentional or artificial selection for a desired trait (such as growth rate or adult body size)

Although not common practice today, some hatchery programs intentionally select for larger fish (or other specific traits). This selection changes the genetic makeup of the hatchery stock, moving it further away from naturally reproducing salmon stocks.

3) Selection resulting from nonrandom sampling of broodstock
The makeup of a hatchery population comes from a selection of wild salmon and/or returning hatchery salmon that are taken into captivity (*i.e.*, broodstock). If, for example, only early-returning adults are used as broodstock, instead of adults that are representative of the population as a whole (*i.e.*, early, mid, and late-returning adults), there will be genetic selection for salmon that return early.

4) Unintentional or natural selection that occurs in the hatchery environment
Conditions in hatchery facilities differ greatly from those in natural environments. Hatcheries typically rear fish in vessels (*i.e.*, circular tanks and production raceways) that are open and have lower and more constant water flow than that which occurs in natural streams and rivers. They also tend to hold fish at higher densities than those that occur in nature. This type of rearing habitat has the potential to alter selection pressures in favor of fish to survive in a hatchery, rather than a natural environment. In addition, artificial mating disrupts natural patterns of sexual selection. In hatcheries, humans select the adult males and females to mate rather than the individual salmonids selecting their own mates. Humans have no way of knowing which fish would make the best natural breeders.

5) Temporary relaxation of selection during the culture phase that otherwise would not occur in the wild
Selection is relaxed up until the time when juveniles are released from the hatchery (because they don't face the same predation and foraging challenges as wild juvenile fish). Fish raised in hatchery environments face very different pressures than those raised in the wild.

<u>Ecological Risks</u>
Hatchery-produced fish often differ from wild fish in their behavior, appearance, and/or physiology. Ecological risks of artificial propagation on wild populations include:

1) Competition for food and territory
Competition between wild and hatchery fish can occur. It is most likely to occur if the fish are of the same species (wild Chinook salmon and hatchery-reared Chinook salmon) and they share the same habitat (quiet, shallow water or deep fast water) and diet.

2) Predation by larger hatchery fish
In situations where hatchery-released juvenile salmonids are larger than wild juvenile salmonids, evidence suggests that, for certain species, hatchery-released larger salmon may eat wild smaller salmon.

3) Negative Social Interactions
Juvenile salmon establish and defend foraging territories through aggressive contests. When large numbers of hatchery fish are released in streams where there are small numbers of wild fish, hatchery fish are more likely to be more aggressive, disrupting natural social interactions.

4) Carrying Capacity Issues
Carrying capacity is a measure of the size of a population that can be supported by a particular ecosystem. Carrying capacity changes over time with the abundance of predators and resources such as food and habitat (including water quantity and quality). When hatchery fish are released into streams where there are wild fish, there can be competition for food and space. Many streams and watersheds are degraded due to habitat degradation. Placing large numbers of hatchery individuals in a stream on top of wild individuals can result in reduced rearing success for all individuals in that stream.

<u>Behavioral Risks</u>
Hatchery environments are different than stream environments. Hatcheries typically rear fish in vessels (*i.e.*, circular tanks and production raceways) that produce sterile environments where there is no underwater structure (*i.e.*, cobbles and wood), little or no overhead cover (such as cover from nearby trees and shrubs), and a predictable food supply. Consequently, hatchery fish tend to have different foraging, social, and predator-avoidance behavior than wild fish.

<u>Overfishing</u>
Large-scale releases of hatchery fish have supported commercial, Tribal, and sport fishing practices for many years. However, large-scale releases of hatchery fish in a mixed-population fishery create a risk of overfishing for wild populations. For example, if fishers are allowed to catch half of the more abundant, hatchery stocks, half of the wild stocks will also be harvested if they occur at the same time and place as the hatchery fish. Because hatchery populations have high survival in the hatcheries, they can generally support higher harvest rates. Wild stocks, on the other hand, are typically much smaller, and their population could be harmed by such high harvest rates.

<u>Fish Health</u>
The effect of disease on hatchery fish and their interaction with wild fish is not well understood. However, hatcheries can have disease outbreaks, and when diseased fish are released, they can transmit disease to wild fish.

Methods:
Three hatcheries are currently operating in the NCCC Domain: the CDFW Mad River Fish Hatchery, the Corps' Don Clausen Hatchery at Warm Springs Dam in the Russian River watershed, and the King Fisher Flat facility on Scott Creek operated by Monterey

Bay Salmon and Trout Project. The Don Clausen and King Fisher Flat facilities are operated as conservation hatcheries for coho salmon, and all three are operated as production facilities for steelhead. They receive considerable oversight from NMFS and CDFW. Conservation hatcheries are not operated for maximum production but are operated with the goal of ensuring genetic integrity of the target population. See Spence *et al*. (2008) for additional information.

Ratings:
Most of the hatcheries in the NCCC Domain were smaller than the production hatcheries in other parts of California but the long history of outplanting has likely adversely affected genetic diversity of steelhead and Chinook salmon to some degree. Disease, particularly bacterial kidney disease, has been a source of concern in regards to the Noyo Egg Collecting Station (ECS) (now closed). In addition, excluding grilse from the Noyo ECS spawning program may have decreased genetic diversity of the Noyo population. Sources of information included personal communications with local experts, hatchery managers, and NMFS and CDFW staff knowledgeable with the operations of the existing facilities. The percent of observed adults of hatchery origin is used as an indicator of relative genetic risk to a population. Use of less than 5 percent as the threshold for low risk is consistent with the approach described in Spence *et al.* (2008). Spence *et al.* (2008) does not provide guidance regarding the degree of risk above 5 percent. The status review for Oregon salmon and steelhead populations in the Willamette and Lower Columbia basins (McElhany *et al.* 2007) describes categories of genetic risk from hatcheries with break points at 10 percent and 30 percent, and this convention is adopted for all steelhead and Chinook salmon populations. The final threat ratings were determined by the following criteria:

High or Very High = Impacts to the population are (or are expected to be) severe. High or very high threats may include a facility operated for the purpose of maximum production with no consideration for genetic impacts to the population. A high threat would mean that greater than 10 percent and less than 30 percent of observed adults are of hatchery origin. Where such data are available, a very high threat would mean that greater than or equal to 30 percent of observed adults are of hatchery origin.

Medium = Impacts to the population are (or are expected to be) moderate but could be reversed or ameliorated. Where such data is available, a medium threat would mean greater than or equal to 5 percent and less than or equal to 10 percent of observed adults are of hatchery origin or there is a salmonid production hatchery in the basin. Medium threats might include a facility operated with minimal regulatory oversight or that takes a significant proportion of a spawning run but attempts to minimize genetic impacts.

Low = Impacts to the population are (or are expected to be) low and easily reversible. Where such data is available, less than 5 percent of observed adults are of hatchery origin and there is no salmonid hatchery is in the basin. An example of low threat would include a conservation broodstock facility operated with significant oversight by regulatory agencies and with backup rearing facilities.

1.5.7 Livestock Farming and Ranching

NMFS defined this threat as domestic terrestrial animals reared in one location (*e.g*., cattle feed lots, chicken farms) or domestic or semi-domesticated animals allowed to roam in the wild and supported by natural habitats (*e.g*., cattle ranching). Livestock grazing is the most widespread land-management practice in western North America, occurring across 70 percent of the western United States (Noss and Cooperrider cited in Donahue 1999). However, in the NCCC Domain, Livestock grazing and ranching is generally concentrated in just a few of the essential or supporting watersheds.

The impacts of livestock grazing in riparian areas have been widely studied. Direct effects include elevated levels of fecal coliform bacteria, nutrients, and oxygen-depleting organic matter (Knutson and Naef 1997). Increased sediment in streams, degraded stream banks and bottoms, altered channel morphology from livestock trampling, lowered ground water tables and reduced streamside vegetation also contribute to degraded fish habitat (Armour *et al.* 1991; Kovalchik and Elmore 1992; Overton *et al.* 1994; Belsky *et al.* 1999; Donahue 1999). Behnke and Zarn (1976) and Armour *et al*. (1991) indicate overgrazing is one of the major contributing factors in the decline of Pacific Northwest salmon. George *et al*. (2002) found cattle trails in California produced 40 times more sediment runoff than adjacent vegetated soil surfaces. In the NCCC Domain, the adverse impacts from large scale cattle grazing are believed less problematic than other areas of California, because it is isolated to a few watersheds.

Methods:
The quality and quantity of information varied significantly between watersheds. Sources of information included watershed assessments, personal communications with local experts, and staff knowledge of individual watersheds, and best professional judgment.

Ratings:
NMFS analysts considered grazing intensity and seasonality, stockyard proximity to the stream channel, damage to riparian zones, and water quality impacts resulting from animal waste and increased erosion. Threats were evaluated for their potential to:

1. Elevate the concentration of water-borne pollutants such as sediment, toxic chemicals/substances (*i.e.*, hormones), and nutrient levels;
2. Alter riparian zone diversity, function, and composition;
3. Alter drainage channels and hydrology (soil compaction); and
4. Simplify channel structure and alter stream bank stability.

The final threat ratings were determined by the following criteria:

High or Very High = Ecosystem function and process are (or are expected to be) severely altered. For example, if the effects of increased sediment, degraded stream banks and bottoms, and altered channel morphology from livestock trampling were severe, the threat would be rated as High.

Medium = Ecosystem function and process are (or are expected to be) moderately altered but could be reversed or ameliorated.

Low = Ecosystem function and process are (or are expected to be) largely intact, slightly altered, and easily reversible. Low ratings would occur in watersheds with little or no Livestock Farming and Ranching activity.

1.5.8 Logging and Wood Harvesting

This threat was defined as harvesting trees and ancillary post-harvest effects of these activities, including changes to hydrologic patterns and increased contribution of water-borne pollutants, such as sediment and elevated nutrient levels. Additionally, this threat includes conversion of timberland (to vineyards, rural residential development, or other detrimental uses) pursuant to CalFire's timberland conversion process.

Many watersheds in the NCCC Domain are heavily forested, particularly in the northern and coastal areas. In these areas, timber harvest is a major land use practice that may threaten listed salmonids and their habitats. Adverse changes to salmonid habitat resulting from timber harvest are well documented in the scientific literature (Hall and Lantz 1969; Burns 1972; Holtby 1988; Holtby and Scrivener 1989; Hartman and Scrivener 1990; Chamberlin *et al.* 1991; Hicks *et al.* 1991a). The cumulative effects of these practices include changes to hydrology (including water temperature, water quality, water balance, soil structure, rates of erosion and sedimentation, channel forms and geomorphic processes (Chamberlin *et al.* 1991)) which affect salmonid habitats. These processes operate over varying time scales, ranging from a few hours for coastal streamflow response to decades or centuries for geomorphic channel change and hill-slope evolution (Chamberlin *et al.* 1991).

Spence *et al*. (1996) summarized the major effects of timber harvest on salmonids as follows: "Riparian logging depletes large woody debris (LWD), changes nutrient cycling and disrupts the stream channel. Loss of LWD, combined with alteration of hydrology and sediment transport, reduces complexity of stream micro- and macro-habitats and causes loss of pools and channel sinuosity. These alterations may persist for decades or centuries. Changes in habitat conditions may affect fish assemblages and diversity." Spence *et al*. (1996) cited studies by McCammon (1993) and Satterland and Adams (1992) showing increased peak flows resulting from alteration of 15-30% of a watershed's vegetation, and concluded "that no more than 15-20% of a watershed should be in a hydrologically immature state at any given time." In many streams, reduced LWD as a result of past forestry practices has resulted in decreased cover and reduced gravel and organic debris storage. Reduced LWD has also decreased pool habitat volume and reduced overall hydraulic complexity (CDFG 2002). LWD also provides cover from predators and shelter from turbulent high flows. Heavy rainfall occurring after timber harvest operations can increase stream bank erosion, landslides, and mass wasting, resulting in higher sedimentation rates than historical amounts. This can reduce food supply, increase fine sediment concentrations that can reduce the quality of spawning gravels, and increase the severity of peak flows during heavy precipitation. Removing vegetative canopy cover increases solar radiation on the aquatic surface, which can increase water temperatures (Spence *et al*. 1996).

Reeves *et al.* (1993) found that pools diminished in frequency in intensively managed watersheds. Streams in Oregon coastal basins with low timber harvest rates (<25%) had 10-47% more pools per 100 meters than did streams in high harvest basins. Additionally, Reeves *et al.* (1993) correlated reduced salmonid assemblage diversity to rate of timber harvest.

Ligon *et al*. (1999) recommend a harvest limitation of 30-50% of the watershed area harvested per decade as a "red flag" for a higher level of review. Recent work in the Mattole River suggests a harvest threshold of 10-20% (Hartwell Welsh, Redwood Sciences Laboratory, personal communication, 2010). Harvest areas of 15 percent of watersheds are considered excessive for some timberlands (Reid 1999).

Timber harvest on non-federal land in California is regulated by the Z'berg-Nejedly Forest Practice Act of 1973 (California Public Resources Code Section 4511 *et seq*.). NMFS believes that the current California Forest Practice Rules are a qualitative improvement over historical practices; unfortunately, their effectiveness in protecting watershed processes that support salmonids has never been established (Dunne *et al.* 2001). The specific inadequacies of the rules have been well-described by state organized committees, state and Federal agencies and scientists (LSA Associates Inc. 1990; Little Hoover Commission 1994; CDFG 1995; CDF 1995; NMFS 1998b; Ligon *et al.* 1999; Dunne *et al.* 2001), BOF Technical Committee 1994; California Senate Natural Resources and Wildlife Committee 1996; BOF Ecosystem Management Committee 1996; LSA Associates 1991; DFG 1993; CDF 1994; NMFS 1997).

Timber harvest and land management planning on National Forests has improved with the implementation of the Northwest Forest Plan (FEMAT 1993). The Northwest Forest Plan provides for protection of refugia by recognizing Key Watersheds and prescribing wide riparian buffers in these watersheds and setting cumulative effects thresholds.

Substantial timber harvesting has occurred in the NCCC Domain. Private and publically-held forestlands currently support many salmonid populations and these species are provided greater protection on forestlands than landscapes subject to most other land use practices. The State and Federal regulatory infrastructure and oversight represent an opportunity to meet recovery goals. The objectives below assume forest practices are being implemented at the minimum standard of the Forest Practice Rules and/or Northwest Forest Plan or HCPs (depending on the targeted population).

Methods:
NMFS analysts considered all operations associated with timber removal within the harvest unit, including skid trails, and construction of landings and yarding corridors. Roads related to timber harvest but located outside the timber harvest plan footprint were evaluated separately under the Roads and Railroads threat. Threats were evaluated for their potential to:

1. Increase water-borne pollutants such as sediment, toxic chemicals, and elevated nutrient levels;
2. Alter riparian zone integrity, diversity, function (*i.e.*, LWD recruitment), and composition;
3. Alter drainage channels and hydrology;
4. Simplify channel complexity and lower stream bank stability; and,
5. Compromise hillslope stability.

The type of activities and rate of harvest were considered to rate the impact of this threat for each watershed. Harvest types were grouped as follows: even aged harvest, uneven aged harvest, conversion, no harvest, and transition. These harvesting types were considered in each determination when feasible to do so.

Additional information considered when making a determination included the following when such information was available or known:
- Was the population or a portion of the population covered by an HCP, Conservation Easement or Forest Certification program?
- Were the landowners known to implement standards higher than standard forest practices (*e.g.*, The Conservation Fund's sustainable forest management on the Garcia River)?

NMFS relied on a suite of resources to make determinations regarding the contribution or level of threat. This information includes watershed assessment documents, HCP documents, personal communications and GIS information on rate of harvest, extent of forestlands, type of harvesting conducted and erosion potential. NMFS also used CalFire's Timber Harvest Plans in digital GIS format, which focused on land use over the last ten years, to analyze the percentage of land managed as timberlands.

Ratings:
The cumulative effects of timber harvest were assessed based on our understanding of the rate and type of harvest and subsequent effects to salmonids. The final threat ratings were determined by the following criteria:

High or Very High = Ecosystem function and process are (or are expected to be) severely altered or impacts to the population are severe. High or Very High threats occur when amelioration of the consequences of this threat are largely irreversible; or include activities that result in a permanent change to the landscape (*e.g*., conversion to agriculture, urban, or other uses or results in long-lived changes to vegetative communities).

Medium = Ecosystem function and process are (or are expected to be) moderately altered or impacts to the population are moderate. Medium threats occur when the consequences of this threat are largely irreversible but could be ameliorated. Includes harvest activities meeting minimum requirements of the CFPRs.

Low = Ecosystem function and process remain largely intact or are slightly altered, and easily reversible. This rating includes activities such as timber harvest that conforms to (or has higher standards beyond) CFPR (*e.g*., Pacific Forest Trust certified).

1.5.9 MINING
NMFS analysts considered all types of mining and quarrying, including instream gravel mining. Extraction of minerals and aggregate has affected fishery resources tremendously, and it continues to degrade salmonid habitat in many areas (Nelson *et al.* 1991).

Gravel extraction (the removal of sediment from the active channel) has various impacts on salmonid habitat by interrupting sediment transport and often causing channel incision and degradation (Kondolf 1993; CDFG 2004). The impacts that can result from gravel extraction include: direct mortality; loss of spawning habitat; noise disturbance; disruption of adult and juvenile migration and holding patterns; stranding of adults and juveniles; increases in water temperature and turbidity; degradation of juvenile rearing habitat; destruction or sedimentation of redds; increased channel instability and loss of natural channel geometry; bed coarsening; lowering of local groundwater level; and loss of LWD and riparian vegetation (Humboldt County Department of Public Works 1992; Kondolf 1993; Jager 1994; Halligan 1997). Terrace mining (the removal of aggregate from pits isolated from the active channel) may have similar impacts on salmonids if high flow events cause the channel to move into the gravel pits.

Mining occurs within many watersheds in the ESU/DPSs, including instream gravel mining on the mainstem Russian, Mad, and Van Duzen rivers. Upslope mining operations include borrow pits and major quarry operations in Soquel Creek.

According to CDFG (2004), while instream gravel extraction has had direct, indirect, and cumulative impacts on salmonids in the recent past, impacts to salmonids have not been documented under the current (post-1995) monitoring and reporting standards developed by CDFW and the mining industry. These standards were incorporated into County Conditional Use Permits; reclamation plans required by the Surface Mining and Reclamation Act; and U.S. Army Corps of Engineer (USACE) Letters of Permission. In 2005, NMFS updated its National Gravel Extraction Guidance (Packer *et al.* 2005). The guidelines summarize the effects of in- and near-stream gravel extraction on anadromous fishes and their habitats, and provide recommendations for avoidance, minimization, and mitigation.

Many rivers continue to suffer the effects of years of channel degradation from the millions of tons of aggregate removed from the systems over time (Collins and Dunne 1990). Most gravel mining operations occur in habitat that is currently considered migration habitat rather than current spawning and rearing habitat. However, some of these instream operations occur in habitats designated as IP-km and are important areas for recovery of listed salmonids.

Methods:
NMFS analysts considered exploration for, developing, processing, storing, and producing minerals and rocks. According to an extensive review, the effects of mining on salmonids were considered minimal beyond the 20 year bankfull channel, so the analysis was focused on that extent (Laird *et al.* 2000). Threats were evaluated for their potential to:

1. Reduce the quantity and quality of stream gravel;
2. Reduce channel complexity;
3. Modify upstream channel sections (*e.g.*, headcuts);
4. Alter riparian zone integrity, diversity, function, and composition;
5. Alter channel geometry and hydrology;
6. Alter stream bank stability;
7. Simplify channels or cause incision and disconnection from its floodplain;
8. Alter or cause the loss of floodplain/estuarine habitats; and,
9. Alter water quality by increasing sedimentation or turbidity, elevating water temperatures, and input of toxic metals.

NMFS used watershed documentation, including GIS data from the USEPA, professional judgment, and consulted with knowledgeable individuals when rating this threat. Information and analyses from biological opinions on gravel mining operations through the NCCC Domain was also considered.

Ratings:

The cumulative effects of mining activities were assessed based on our understanding of the rate and type of mining, and subsequent effects to salmonids. The final threat ratings were determined by the following criteria:

High or Very High = Ecosystem function and process are (or are expected to be) severely altered. Activities that rate as high or very high threats may include instream gravel mining and mining activities within the 20-year bankfull channel.

Medium = Ecosystem function and process are (or are expected to be) moderately altered but could be reversed or ameliorated. Activities rating as a medium threat may include activities outside of the 20-year bankfull channel.

Low = Ecosystem function and process are (or are expected to be) largely intact, slightly altered, and easily reversible. Activities that rate as low threats generally occur outside of the 100-year floodplain.

1.5.10 RECREATIONAL AREAS AND ACTIVITIES

Recreational activities (legal and illegal) may alter, destroy, impair, and/or disturb habitats and salmonids. The category covers many types of activities that may directly and indirectly impact salmonids such as increased sedimentation to salmon streams due to off-road vehicle use in the upper portion of a watershed; concentrated animal waste discharge from equestrian facilities; dumping of chlorinated water from swimming pools into watercourses; loss of riparian vegetation due to construction and operation of on-stream recreational summer dams which lead to increased water temperature, *etc*.

Recreational areas and activities are numerous and diverse in the NCCC Domain. This threat category is often more likely to occur in areas with high human populations and includes legal and illegal activities and activities having temporary or permanent impacts.

A number of actions have been undertaken to address some of the impacts related to recreational areas and activities. These actions include development of a white paper by NMFS regarding the impacts of recreational summer dams and increased enforcement and oversight by NMFS and CDFW regarding installation of these facilities. However, many actions and their impacts remain unaddressed and impacts to salmonids and their habitat continue.

Methods: NMFS analysts considered use of off-road vehicles, mountain bike activities, trail maintenance, equestrian uses, summer dams, amusement parks, and golf courses. Stresses evaluated include:

1. Excessive erosion and sedimentation;

2. Ford crossings and effects of ORV use in streams;
3. Introduction of pollutants, garbage, toxic chemicals, and changes in nutrient levels;
4. Alteration in riparian zone integrity, diversity, function, and composition;
5. Alteration in streambank stability;
6. Diversion and/or impoundment of streams; and,
7. Channel simplification, incision and disconnection from its floodplain.

Ratings:
The category of Recreational Areas and Activities encompasses a diverse array of land and water uses and types of recreation. No one centralized database is available that adequately assesses this threat category. Staff used available watershed assessments and relied heavily upon their professional experience from working within the various watersheds to assess the degree of impact posed by this threat. The final threat ratings were determined by the following criteria:

High or Very High = Ecosystem function and process are (or are expected to be) severely altered. High or Very High threat ratings may include heavy ORV use in riparian channels that results in the destruction or modification of stream banks and riparian vegetation or permanent alteration of high quality habitat due to construction of recreational facilities.

Medium = Ecosystem function and process are (or are expected to be) moderately altered but could be reversed or ameliorated. Medium threat ratings may include extensive mountain biking trails on steep slopes with substandard maintenance oversight.

Low = Ecosystem function and process are (or are expected to be) largely intact, slightly altered, and easily reversible. Low threat rating may include low impact activities such as hiking on designated and properly located and maintained trails.

1.5.11 Residential and Commercial Development

Urban, industrial, suburban, or rural residential developments result in permanent alterations of the natural environment and encroachment on floodplains and into riparian areas. Development includes military bases, factories, shopping centers, resorts, *etc*. This threat includes the physical and social (*i.e*., homeless encampments) consequences of development such as increased impervious surfaces, increased runoff, changes to the natural hydrograph (*e.g.,* flashy flows), household sewage, urban wastewater, increased sedimentation, industrial effluents, garbage and solid waste.

Urbanization not only affects habitat in obvious ways – for example, direct loss of habitat, channelization of streams, degradation of water quality, and dewatering of streams – but it can also affect habitat in less obvious ways by altering and disrupting ecosystem processes that can have unintended impacts to aquatic ecosystems through increased flooding, channel erosion, landslides, and aquatic habitat destruction (Booth 1991).

According to CDFG (2004) the structure of a biological community and abundance and diversity of aquatic organisms are greatly altered by urban impacts on channel characteristics and water quality. Wang *et al.* (1997) found high urban land use was strongly associated with poor biotic integrity and was associated with poor habitat quality. Fish populations are also adversely affected by urbanization. Limburg and Schmidt (1990, as cited in Spence *et al.* 1996) found a measurable decrease in spawning success of anadromous species in Hudson River tributaries that had 15% or more of the watershed in urban development. Wang *et al*. (2003) found a strong negative relation between urban land cover in the watershed and the quality of fish assemblages in cold water streams in Wisconsin and Minnesota. Other studies documented pollution associated with urban areas as causing impacts to juvenile Chinook salmon, including suppressed immune response due to bioaccumulation of PCBs and PAHs, increased mortality associated with disease, and suppressed growth (Spence *et al*. 1996).

Steelhead and Chinook salmon are present in many urbanized watersheds; however, in general, those habitats are more impacted and populations are less robust than in less urbanized areas. Impacts of residential and commercial development are numerous, and these impacts are often closely interrelated with other activities evaluated separately in this document (*i.e.*, roads and channel modification).

Within the NCCC Domain, urban, rural residential and suburban development occurs in many of the watersheds targeted for recovery actions. Many large cities are located within the Domain, particularly within the San Francisco Bay Area. Cities and towns in proximity to targeted watersheds include Eureka, Ukiah, Fort Bragg, Santa Rosa, San Rafael, Napa, Alameda, Oakland, Union City, San Jose, Half Moon Bay, Capitola, Santa Cruz, *etc*. Suburban and commercial areas typically occur in or near the large urban areas. Rural residential housing is present throughout the Domain with varying degrees of concentration.

Methods:
NMFS analysts evaluated the impact of development for its potential to:

1. Introduce pollutants, garbage, urban/industrial wastewater, sedimentation, toxic chemicals, and changes in nutrient levels (“shock pollution” aka first flush);
2. Alter riparian zone integrity, diversity, function, and composition;
3. Alter stream bank stability;
4. Simplify channels, or cause incision and disconnection from the floodplain;
5. Alter drainage channels and hydrology;

6. Increase stormwater runoff; and,
7. Induce growth and associated consequences.

Ratings:
NMFS analysts evaluated GIS analysis of the percentage of watershed with impervious surfaces, watershed specific assessments, staff knowledge of watersheds and ongoing practices, and best professional judgment. The final threat ratings were determined by the following criteria:

High or Very High = Ecosystem function and process are (or are expected to be) severely altered or impacts to the population are severe. High or Very High threats occur when amelioration of the consequences of this threat is largely irreversible. High or Very High threat ratings may occur in watersheds with extensive urban development resulting in extensive modification of riparian zones from historical conditions.

Medium = Ecosystem function and process are (or are expected to be) moderately altered or impacts to the population are moderate. Medium threats occur when the consequences of this threat are largely irreversible but could be ameliorated.

Low = Ecosystem function and process remain largely intact or are slightly altered, and easily reversible.

1.5.12 ROADS AND RAILROADS

Studies have documented the degradation that occurs to salmonid habitats as a result of forest, rangeland and other road and highway networks (Furniss *et al.* 1991). Roads alter natural drainage patterns and accelerate erosion processes causing changes in streamflow regimes, sediment transport and storage, channel bed and bank configuration, substrate composition, and stability of slopes adjacent to roads systems (Furniss *et al.* 1991).

This threat included roadways (highways, secondary roads, primitive roads, bridges & causeways), associated infrastructure (*e.g.* culverts, crossings, *etc.*), and dedicated railroad tracks. It also includes all roads (including mainline logging roads) not associated with the site-specific footprint of timber harvest activities.

A number of actions have been undertaken to address roads and road-related threats. Through FishNet 4C and the Five Counties Salmon Conservation Program, an evaluation of county road-related issues, including passage and ongoing maintenance has been conducted. A Road Maintenance manual and training for road staff is an ongoing program in the coastal counties but is absent from many of the counties surrounding San Francisco Bay (including Contra Costa, Solano, Alameda, San Francisco, Napa, and Santa Clara). The key focus of this program is on implementing best management practices related to protecting water quality, aquatic habitat and salmonid fisheries. The guidelines outlined in the manual address most routine and emergency road-related maintenance activities undertaken by County Departments of Public Works, Parks, and Open Space Districts, and they also address common facilities such as spoils storage sites and maintenance yards. The guidelines apply to county facilities and activities and not to private development.

Restoration of problematic private and public roads is a large part of the CDFW restoration program and occurs in many of the targeted watersheds in the ESU/DPSs. The magnitude of road-related problems in the ESU/DPSs is significant and it is anticipated that it will take many years to adequately address the most problematic roads. Additionally, many roads, particularly private non-timber roads, are poorly maintained and not subject to routine maintenance. Chronic sediment input from these roads is a major problem in some watersheds.

Methods:
Graham Matthews and Associates (1999) linked increased road densities to increased sediment yield in the Noyo River. NMFS (1996a) guidelines for salmon habitat characterize watersheds with road densities greater than three miles of road per square mile of watershed area (mi/mi^2) as "not properly functioning" while "properly functioning condition" was defined as less than or equal to two miles per square mile, with few or no streamside roads.

For coastal areas of California, road densities were calculated using roads included in CalFire timber harvest GIS data. For inland areas, road densities were calculated using a roads theme produced by Legacy— The Landscape Connection which uses multiple sources.

Ratings:
Threats from Roads and Railroads were evaluated for their potential to affect:

1. Chronic and acute introduction of sediment from surface erosion and drainage;
2. Delivery of large quantities of sediment from road crossing or mass wasting associated with roads;
3. Passage impairment or blockage due to culverts, bridges, *etc*.;
4. Risks of spills;
5. Alteration of drainage channels, hydrology, infiltration and runoff;
6. Alteration in riparian zone diversity, function, and composition;
7. Channel simplification, incision and disconnection from its floodplain;
8. Alteration in channel and streambank stability;
9. Alteration or loss of floodplain or estuarine habitats;
10. Water-borne pollutants such as sediment, chemicals, and adverse changes in nutrient levels; and,

11. Growth-inducing consequences.

The final threat ratings were determined by the following criteria:

High or Very High = Ecosystem function and process are (or are expected to be) severely altered or impacts to the population are severe. High or Very High threats occur when amelioration of the consequences of this threat is largely irreversible. A High or Very High threat may occur in watersheds with high road densities, poor road maintenance practices, numerous stream crossings, and road placement on unstable areas and adjacency to stream zones.

Medium = Ecosystem function and process are (or are expected to be) moderately altered or impacts to the population are moderate. Medium threats occur when the consequences of this threat are largely irreversible but could be ameliorated.

Low = Ecosystem function and process remain largely intact or are slightly altered, and easily reversible.

1.5.13 SEVERE WEATHER PATTERNS

Severe weather patterns were defined as short-term extreme variations (droughts and floods) to seasonal average/mean rainfall during a calendar "water year" with attendant effects to streamflow and riparian conditions, and long-term climatic changes outside the range of natural variation that may be linked to global climate change and other large-scale climatic events.

Droughts can have a variety of negative impacts on salmonids and other fish populations at several points in their life cycles. Adult salmon can experience difficulties reaching upstream spawning grounds during certain low-flow conditions. Low flows can also increase pre-spawn mortality rates in returning adult salmonids when high adult escapement coincides with elevated water temperatures, low dissolved oxygen levels, and increased disease transmission between fish (CDFG 2003). Drying streams can severely lower juvenile rearing habitat and carrying capacity. Some salmonids spawn in channel margins, side channels and smaller tributaries, and spawning for those species would have to occur in mainstem waters if off-channel and tributary habitat is unavailable because of low flows. Where this occurs, redds within the mainstem river channel may be more susceptible to bed scour during the fall and winter (Wash. Dept. Fish and Wild. http://wdfw.wa.gov/conservation/drought/impacts.html). In other cases, instream flow can drop after the salmon spawn, leaving redds dewatered.

High flows associated with storms and floods can result in complete loss of eggs and alevins as they are scoured from the gravel or buried in sediment (Sandercock 1991;

NMFS 1998a). Juveniles and smolts can be stranded on the floodplain, washed downstream to poor habitat such as isolated side channels and off-channel pools, or washed out to sea prematurely. Peak flows can induce adults to move into isolated channels and pools or prevent their migration through excessive water velocities (CDFG 2004).

Droughts and floods are a natural phenomenon in the NCCC Domain. Nonetheless, drought impacts can result in depressed salmonid populations years later, when those salmonids would be returning as adults. Flooding can have beneficial effects: cleaning and scouring of gravels; transporting sediment to the flood plain; moving and rearranging LWD; recharging flood plain aquifers (Spence *et al.,* 1996); allowing salmonids greater access to a wider range of food sources (Pert 1993); and maintaining the active channel.

Streams can be drastically modified by erosion and sedimentation in large flood flows almost to the extent of causing uniformity in the stream bed (Spence *et al*., 1996). After major floods, streams can take years to recover pre-flood equilibrium conditions. Flooding is generally not as devastating to salmon in morphologically complex streams, because protection is afforded to the fish by the natural in-stream structures such as LWD and boulders, stream channel features such as pools, riffles, and side channels and an established riparian area (Spence *et al*. 1996).

Climate change may profoundly affect salmonid habitat on a regional scale by altering streamside canopy structure, increasing forest fire frequency and intensity, elevating instream water temperatures; and altering rainfall patterns that in turn affect water availability. These impacts are likely to negatively impact salmonid population numbers, distribution, and reproduction.

Salmonids at the southern extent of the NCCC Domain may be more vulnerable to changes in water availability and instream temperatures than populations in northern areas. Significant alteration in the instream and near-stream environments due to climate change may result in further range contraction for salmonids and a reduction in overall habitat availability in the more resilient watersheds.

In the NCCC Domain there is increased pressure for limited water resources in many of the targeted watersheds. This problem is most severe in the southern part of the NCCC Domain where rainfall is generally less than in the northern areas. Compounding this problem is a larger human population in the southern streams with greater demand for water and an attendant higher number of instream water diversions.

Future effects of climate change and the expected sea level rise in California, such as lost estuarine habitat, reduced groundwater recharge and base-flow discharge, with associated rises in stream temperature and demand for water supplies may be seen.

Smaller (remnant) populations in such areas are likely at most risk from climate change. Appendix B: Climate Change includes an assessment and discussion of potential implications of climate change for steelhead and Chinook salmon populations and their habitat in northern and central coast areas of California.

Methods:
Droughts were evaluated in the context of available information regarding ongoing water diversions coupled with the effects of drought. A variety of resources were used to evaluate this potential impact, including individual watershed assessments, briefings with NMFS, CDFW, and others familiar with individual watersheds and existing diversions, *etc*.

For the threat of flooding, staff knowledge of watersheds and ongoing practices, *etc*., were examined. In addition, staff reviewed models related to climate change where they predicted increased storms or flooding.

For climate change we used existing information on the current distribution of extant populations and areas targeted for recovery, and evaluated current stresses into the future.

Ratings:
Threats from Severe Weather Patterns related to droughts were evaluated for their potential to affect:

1. Insufficient flows to facilitate egg incubation, juvenile rearing, smolt emigration, and juvenile immigration;
2. Poor water quality leading to increased instream temperatures, low DO, decreased food availability, increased concentrations of pollutants, *etc*.;
3. Earlier than normal water diversion for anthropogenic purposes; and,
4. Insufficient flows to breach sandbars at river mouths.

Threats related to flooding were evaluated for their potential to:

1. Increase the frequency, duration, and magnitude of flooding beyond natural conditions;
2. Require flood control or management actions;
3. Cause loss of riparian and instream habitat attributes;
4. Increase frequency of channel scour beyond natural conditions; and,
5. Increase turbidity beyond natural conditions.

Threats related to climate change were evaluated for their potential effects to cool water refugia, additional demands on existing water supplies, and changes in vegetation patterns. Threats were evaluated for their potential to:

1. Elevate instream water temperatures and alter historical hydrologic patterns; and,
2. Alter the composition of native plant communities, which may adversely alter riparian process and function.

The final threat ratings were determined by the following criteria:

High or Very High = Ecosystem function and process are (or are expected to be) severely altered. High or Very High threat ratings may occur in heavily urbanized watersheds subjected to extensive diversion, areas with historical and ongoing instream modification conducted for flood control purposes, and where circumstances preclude future opportunities to protect critical refugia habitats.

Medium = Ecosystem function and process are (or are expected to be) moderately altered but could be reversed or ameliorated.

Low = Ecosystem function and process are (or are expected to be) largely intact, slightly altered, and easily reversible. Low threat rating may occur in watersheds with little urban interface, few diversions, intact floodplains, and where instream habitat forming features (such as LWD) are present and are not routinely removed.

1.5.14 Water Diversions and Impoundments

Water diversion and impoundments include appropriative and riparian surface water diversions and groundwater pumping resulting in changes to water flow patterns outside the natural range of variation. This threat includes use, construction, and maintenance of seasonal dams for water diversions.

The adverse impacts to salmonids due to water diversions and impoundments are numerous and include:

1. Delay and/or prevention of upstream and downstream migration and reduced overall survival of migrants;
2. Entrainment of juvenile salmonids at unscreened or inadequately screened diversions;
3. Impingement of juvenile salmonids from high approach velocities or low sweeping velocities at fish screens;
4. Elevated predation levels due to concentrating juveniles at diversion structures;
5. Disruption of normal fish schooling behavior caused by diversion operations, fish screen facilities, or channel modifications;

6. Elimination, reduction, and/or impairment of rearing habitat quality and quantity;
7. Dewatering of redds; and
8. Reduced food production.

Water issues are often handled in the regulatory or legal arena due to its relative scarcity in California. Summer baseflow is a critical attribute that is degraded in many streams across the NCCC Domain. A substantial amount of salmonid habitat has been lost or degraded as a result of water diversions and groundwater extraction (KRBFTF 1991; CDFG 1997). The nature of diversions varies from major water developments which can alter the entire hydrologic regime in a river, to small domestic diversions which may only have a localized impact during the summer low flow period. In some streams the cumulative effect of multiple small legal diversions may be severe. Illegal diversions are also believed to be a problem in many streams throughout the NCCC Domain.

Water is the most important of all habitat attributes necessary to maintain a viable fishery and, based on the last 150 years of water development in California, one of the most difficult threats to address effectively for the benefit of salmonids. Few restoration projects address water because in large part, it is a contentious issue. Diversions are subject to regulation by the State Water Resources Control Board – Division of Water Rights through the appropriative water rights process, and by the CDFW under California Fish and Game Code (FGC) § 1600 *et seq*. (which requires notification of CDFW for any substantial flow diversion and a lake or streambed alteration agreement if CDFW determines that the activity may substantially adversely affect fish or wildlife resources), FGC § 2080 *et seq*. (California Endangered Species Act take authorization), and FGC § 5937 (which requires a dam owner to allow sufficient water to pass through a fishway or, in the absence of a fishway, to allow sufficient water to pass below a dam to maintain fish in good condition). NMFS has authority under the ESA to regulate the take of threatened salmonids by diversions.

Many watersheds or their tributaries are listed as being fully appropriated and, for some, water rights have been allocated through court adjudication (*e.g*., Soquel Creek, San Gregorio Creek). These determinations by the Division of Water Rights and court adjudications usually did not consider salmonid habitat needs at a level that could be considered sufficient to conserve listed salmonids. The use of wells adjacent to streams is also a significant and growing issue in some parts of the NCCC Domain. Extraction of flow from such wells may directly affect the adjacent stream, but is often not subject to the same level of regulatory control as diversion of surface flow. Site specific groundwater studies are required to determine a direct connection between surface flow and groundwater, and these are often very costly and take a significant amount of time to complete.

Methods:

A variety of resources were used to evaluate the impacts of water diversion and impoundment. As part of the CCC coho salmon recovery planning process, fisheries biologists from CDFW and Regional Water Quality Control Boards were invited to participate in a structured decision-making process to provide individual opinions regarding flow conditions for specific habitat attributes, and also considered diversion and impoundments for many of the watersheds with populations evaluated in the NCCC Domain. Workshop participants were asked to individually rate the hydrologic setting, the degree of exposure to flow impairments, and the intensity of those impacts for 23 CCC coho salmon populations. Where applicable, these data were used to assess conditions in watersheds with co-concurrent populations of steelhead and Chinook.

For other watersheds, GIS analysis of known diversion points, and the Pacific States Marine Fisheries Council Passage Assessment Database (PSMFC 2006) were reviewed. NMFS GIS watershed characterizations, NMFS staff knowledge of watersheds and ongoing practices, *etc*., were also examined.

Ratings:
Threats were evaluated for their potential to affect:

1. Water diversion and withdrawal, legal and illegal;
2. Chronic and acute introduction of sediment from surface erosion and drainage;
3. Passage impairment or blockage;
4. Alteration of drainage channels and hydrology;
5. Alteration in riparian zone diversity, function, and composition;
6. Alteration in channel and streambank stability;
7. Alterations or loss of floodplain and/or estuarine habitats due to reduced freshwater inflow;
8. Water-borne pollutants such as sediment, chemicals, and adverse changes in nutrient levels;
9. Growth-inducing consequences;
10. Changes in water flow, fish habitat, and temperature;
11. Loss of gravel recruitment to downstream areas;
12. Dewatering and flow reductions; and
13. Delay in sandbar breaching.

High or Very High = Ecosystem function and process are (or are expected to be) severely altered or impacts to the population are severe. High or Very High threats occur when amelioration of the consequences of this threat are largely irreversible. This could include large scale water projects and impoundments.

Medium = Ecosystem function and process are (or are expected to be) moderately altered or impacts to the population are moderate. Medium threats occur when the consequences of this threat are largely irreversible but could be ameliorated.

Low = Ecosystem function and process remain largely intact or are slightly altered, and easily reversible. Low threats occur in watershed with little or no diversions or impoundments where the historic hydrology is unimpeded.

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